AMERICAN MACHINIST

A JOURNAL FOR MACHINISTS, ENGINEERS, FOUNDERS, BOILER MAKERS, PATTERN MAKERS AND BLACKSMITHS.

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Special Planer.

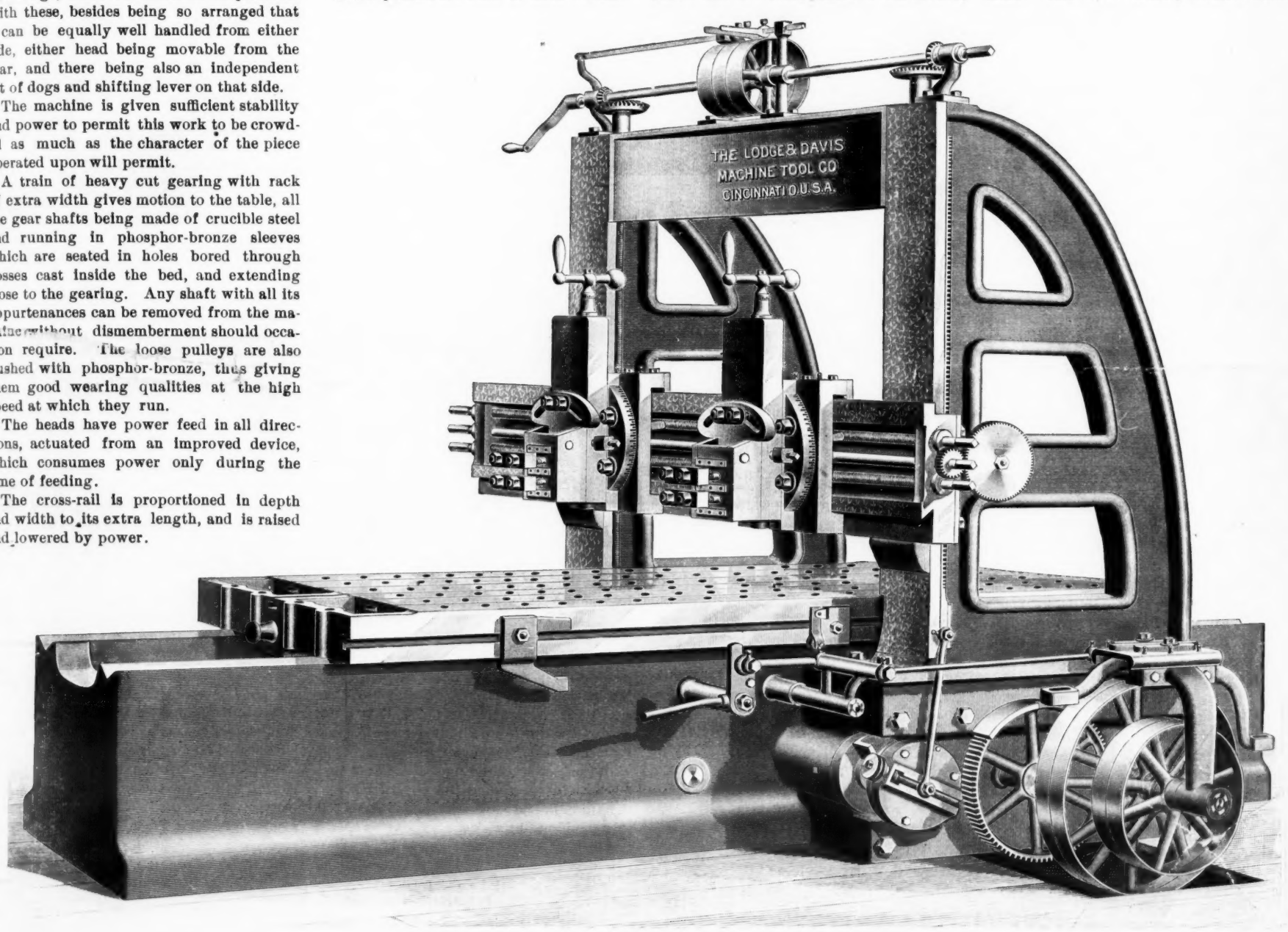
We illustrate herewith a planer designed with special reference to such work as is done by builders of printing presses, wood-working and book-binders' machinery, who require relatively great distance between uprights compared to the other dimensions of the machine. This is a class of work, too, on which two heads can usually be used to advantage, and the machine is provided with these, besides being so arranged that it can be equally well handled from either side, either head being movable from the rear, and there being also an independent set of dogs and shifting lever on that side.

The machine is given sufficient stability and power to permit this work to be crowded as much as the character of the piece operated upon will permit.

A train of heavy cut gearing with rack of extra width gives motion to the table, all the gear shafts being made of crucible steel and running in phosphor-bronze sleeves which are seated in holes bored through bosses cast inside the bed, and extending close to the gearing. Any shaft with all its appurtenances can be removed from the machine without dismemberment should occasion require. The loose pulleys are also bushed with phosphor-bronze, thus giving them good wearing qualities at the high speed at which they run.

The heads have power feed in all directions, actuated from an improved device, which consumes power only during the time of feeding.

The cross-rail is proportioned in depth and width to its extra length, and is raised and lowered by power.



SPECIAL PLANER.

The bed has U-shaped cross-girts placed at intervals of about 24", and is of such depth as to dispense with legs, thus affording a bearing its full length on the foundations.

The table has a wide bearing in the V's, seated by scraping, and is deep enough to prevent springing when heavily weighted. T-slots are planed and bolt holes drilled and reamed out of the solid. Extra lengths of work may be conveniently clamped to the table, owing to the bolt holes being drilled beyond the pockets. Lubrication is thoroughly provided for by means of cone-shaped rollers placed in oil pockets at suitable places in the bed.

Steel rollers are placed at points of contact on the shifting device, effectually preventing abrasion which usually takes place on these surfaces. The rear dog has an arrangement which permits of the table being run from under the tool for the purpose of examining the work. The reverse is accomplished without shock or jar by the use of high belt speeds and an improved lock-shifting device, which removes one belt from the driving pulley before the other is shifted in its place.

These planers are built in three widths—42", 48", and 54", with a common height of 38" to plane any length, by the Lodge & Davis Machine Tool Co., Cincinnati, O.

The value of saving something from wages is very well illustrated in France just now. In the universal business stagnation in Europe the French workman suffers less than any other, because, and especially if he is a married man, it is almost certain that he has something laid by from the wages he received in times of good trade.

Increase in the German export trade is believed in England to be due to the brilliant success achieved by Germany at the Columbian Exposition.

Theory of Steam Engine Governors—III.

BY J. BEGTRUP.

As a help to a better understanding of the following, I would recommend my two previous articles of October 19th and December 14th.

I have in the last article analyzed the oscillatory motion of the governor ball and shown that as a consequence of this motion, there will be a slight fluctuation in the speed of the engine, and thus an unbalanced force y, is called into action, which would increase the oscillation, if not checked by a frictional resistance. The friction I have considered is the friction of the journals of the governor, and such friction of the valve gear as must be overcome by the action of the governor. This friction when reduced to the center of gravity of the ball was represented by a line parallel to the base line in the diagram of motion. I shall now explain the effect of "friction of rest" on the stability of the governor. By friction of rest is meant the frictional resistance to sliding between two surfaces relatively at rest. A very simple experiment will demonstrate that friction of rest is greater than friction of motion. Put a small, heavy body on a slanting surface and increase the inclination till the body commences to move, then repeat the experiment, but strike the supporting surface so as to cause a slight vibration, motion will then commence at a smaller inclination than in the first experiment, and this will invariably be the case with any kind of material when not lubricated. This is, of course, because motion is started by the vibration and thus friction of rest immediately reduced to friction of motion. It may be that with abundant lubrication and light pressure, friction of rest will be the same as friction of motion, and this will be very nearly the case with rolling contact. It can easily be shown that friction of rest, whenever it is in excess of friction of motion, is very objectionable in governors, much more so than friction of motion, and when we find that a governer is apt to race on account of friction it may be that friction of rest, and not friction of motion, is to blame for it, for by the oscillatory motion of the governor weights there will be intervals of rest, and friction of rest may therefore have a considerable influence

on the motion. It is also known from experiments that the longer the surfaces remain in contact without sliding the greater will friction of rest be, and as friction generally will increase the time of rest between oscillations it follows that friction of rest will also be increased thereby, and thus we have one good reason why sliding friction should be reduced as much as possible in governors. But it must not be forgotten that some friction is necessary for stability, and if for instance the governor weights were made to turn on hard steel edges so as to leave no friction on these bearings, and with not enough friction in the valve gear to absorb the energy of force y, it might be necessary to increase the friction in order to obtain stability. But as we have several means by which the force y, may be reduced so that only a small amount of friction will be needed, such means should always be applied or rather taken into consideration when designing the governor, for then it might never be necessary to increase the sliding friction in order to obtain stability.

In Fig. 19, a, b, is the line of the reciprocating force y_o, and the rectangle $a\ h$ represents the energy that may be absorbed by friction while the ball moves from a to b. By limit of stability, that is when $a\ o = o\ b$, the area of force y, must be equal to the area of friction, and in that case area y, would be equal to the area of rectangle $a\ h$, and by smaller oscillations the area of useful friction and of force y, would be represented by smaller rectangles as shown in the figure. Let there be an excess of friction of rest above friction of motion and let us call this excess "starting friction"; then if a, e represents starting friction there will be an initial increase of force y, equal to a, e, and area y, will be increased by an amount equal to the rectangle $e\ h$, but area of useful friction will not be increased, for as soon as motion commences the starting friction disappears and $a\ h$ will be the rectangle of friction as if there were no starting friction.

We shall, therefore, have an excess of positive energy represented by rectangle $e\ h$, and the oscillation will consequently be increasing. Thus we see that starting friction will increase the energy of motion without increasing the energy of resistance, it increases the objectionable energy of force y, without increasing the energy-absorbing capacity of friction. Such is not the case with friction of motion for this will increase energy y, but it will also increase the energy-absorbing power to the same extent. It is a condition of stability that the oscillation shall be decreasing, and we must therefore have area y, smaller then area of friction; for instance, area y, to area of friction as 3 to 4, and this ratio would remain constant for any extent of the oscillation if there were no starting friction, and the oscillation would then be decreasing in geometrical progression, but if we now to any of the smaller rectangles representing energy y, add the rectangle due to starting friction, the height of which is constant and equal to a, e we shall by a sufficiently small oscillation obtain an area y,, which is equal to the area of friction, and we have then arrived at a constant limit for the oscillation where no further reduction of the motion is possible. The effect of starting friction will therefore be to keep the ball oscillating about its position of equilibrium, and this will cause a continuous fluctuation in the speed of the engine. It would be a state of instability, but could not properly be called "racing," and this fluctuation in speed may not be of much consequence except in special cases, for instance, by electric light plants.

Any irregular action of the governor can always be detected by the steam indicator or by a sensitive tachometer. It should, however, be understood that while a tachometer will show any irregularity in the speed of the engine care must be exercised in the conclusions we draw from the showing of the tachometer, for these instruments are generally constructed on the principle of a spring governor, and will therefore be liable to oscillations independent of the motion of the engine.

The reciprocating force of the oscillation in a tachometer is like the force y_o in a governor; but as the angle of inclination of this force in a tachometer is much greater than in a governor the motion will be correspondingly quicker, and the tachometer will therefore give a nearly true representation of variations in speed. Vibrations of the tachometer belt or the least amount of friction in the instrument itself will keep the hand continually moving, and if we want to investigate the action of a governor or engine by a tachometer we should first observe the action of the tachometer when the stop valve is open just enough to run the engine nearly up to speed, but not enough to call the governor into action, for this will exclude any irregularity due to the governor and exhibit any irregularity due to the tachometer or the belt. As a rule friction in the tachometer is observable by a spasmodic action of the hand. The steam indicator will certainly show the action of the governor if the load can be kept constant during a few seconds, which should not be a difficult matter. The action of a gravity governor and of throttling governors generally is apparent by direct observation. Throttling governors are not subject to vibrations, as they have no reciprocating valve gear, and a slight amount of friction will therefore cause incessant oscillation of the balls of such governors, but as the intervals of rest are comparatively long the motion appears as small independent movements repeated at regular intervals.

In all automatic cut-off governors the intermittent action of the valve gear will have some effect, and it may cause vibrations by which starting friction, if it exists, will be made ineffective, and the bad effect of friction of motion will be greatly diminished.

But then there is another reason why friction should be avoided. It prevents the governor from acting promptly and may, therefore, greatly increase the instantaneous variation in speed caused by a change in load or steam pressure, for it is evident that the speed of the engine must vary to such an extent that an unbalanced centrifugal or centripetal force sufficient to overcome the friction is brought into action. This would not be absolutely true in all cases when we take the action of reciprocating parts in consideration, but it would be nearly true, and such action may for the present be ignored. By large oscillations the motion of the ball from one position to another will cause a noticeable variation in speed of the engine, but by smaller oscillations the variation due to friction is of more consequence. This can best be illustrated by an example. From the weight of the ball, its radius of rotation and the speed of the governor is computed the centrifugal force. Let it be 400 pounds and let all the friction be equivalent to a resistance of 20 pounds or 5 per cent. of centrifugal force acting at the center of the ball in a radial direction, then the speed must vary to an extent of $2\frac{1}{2}$ per cent. before the governor can commence to act; for centrifugal force $= k\ n^2$, where k is a factor depending on the weight and radius of rotation, and n is rotative speed; add $2\frac{1}{2}$ per cent. to the speed and then centrifugal force

$$= k\ n^2 \left(1 + \frac{2\frac{1}{2}}{100}\right)^2$$

$$= k\ n^2 \left(1 + \frac{5}{100} + \frac{25}{40{,}000}\right)$$

or $k\ n^2\left(1 + \frac{5}{100}\right)$ nearly, that is, by adding $2\frac{1}{2}$ per cent. to rotative speed we increase centrifugal force by 5 per cent., or, generally, a variation of 9 per cent. in rotative speed gives a variation of 29 per cent. in centrifugal force within such limits as occur in practice. Let some load be thrown off the engine, then there will be an increase of $2\frac{1}{2}$ per cent. in speed to overcome friction and an outward movement of the ball will follow, but it will move beyond its position of equilibrium, and before the return motion there must be a diminution of $2\frac{1}{2}$ per cent. to mean speed, and of $2\frac{1}{2}$ per cent. more to overcome friction. The smallest variation in load or steam pressure will therefore cause an instantaneous variation of 5 per cent. in speed. Or, generally, if the resistance of friction is 9 per cent. of centrifugal force there will be an instantaneous variation in speed of 9 per cent. If, therefore, centrifugal force can be increased without increasing friction in the same proportion the result will be less instantaneous variation. I have not taken into consideration the effect of the reciprocating force y_o, for the oscillation is supposed to be so small that this force will be of no consequence compared with friction.

It is quite possible that in some cases the experimenter would apparently obtain better results from a governor by reducing the centrifugal force, or by applying two centrifugal weights in opposition to each other,

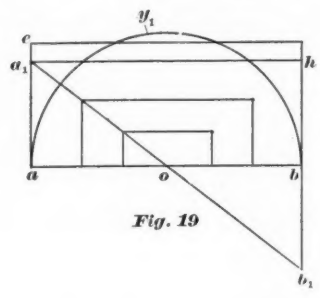


Fig. 19

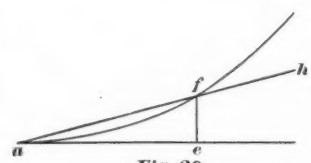


Fig. 20

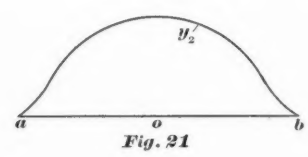


Fig. 21

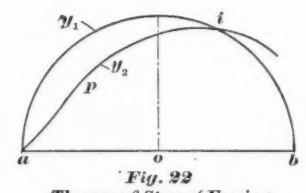


Fig. 22
Theory of Steam Engine Governors. 3
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he would certainly get more instantaneous variation by such scheme, but as some friction is needed for stability, and as the amount of friction needed is in direct proportion to centrifugal force multiplied by the motion of the center of gravity of the centrifugal weight or weights it is quite likely that with the reduced centrifugal force he would have enough friction, while with the greater centrifugal force he would not have enough, and the governor would therefore in that case be apt to race; but this would not be a desirable way to obtain stability.

It was shown in the last article that the energy which must be absorbed by friction for each half oscillation is proportional to the amplitude of the oscillation squared. In Fig. 20, let the amplitude be measured from a along the base line, the corresponding ordinate to the slanting line $a\ h$ may then represent the friction required; for instance, let $a\ e$ be the amplitude, then $e\ f$ represents the friction required for a half oscillation of that amplitude. Suppose now that the whole frictional resistance of the governor system is represented by the ordinate $e\ f$, then this friction would be insufficient for the absorption of the energy of oscillations larger than $a\ e$, and it will therefore be necessary to introduce an additional frictional resistance. An increase of sliding friction would, for reasons which have been explained, be undesirable, but there would be no such objection to fluid resistance. By fluid resistance is meant the resistance of a fluid when forced through an orifice or agitated in any suitable manner. The energy expended by such operation is all converted into heat, as is the energy absorbed by sliding friction. Fluid resistance in governors is most commonly obtained by a so called "dash pot," which is similar to the dash pot used on Corliss engines, where the confined air acts as a cushion to prevent shocks by the sudden closing of the valve; "dash pot" is therefore here an appropriate name; but the object with such a contrivance when applied to a governor is to dispose of superfluous energy much in the same manner as a brake; that is, the motion of the governor weights is gradually reduced by movements of the piston against the fluid, and "pump brake" would therefore in this case be a more suitable name. According to a general law of fluid motion, and particularly according to Rankine, the resistance of the fluid in a pump brake varies directly as the square of the velocity of the piston, and as the piston moves in union with the governor ball, it follows that the greatest resistance will occur shortly after the ball has passed its position of equilibrium. In Fig. 21, let the motion of the ball be from a to b, and let the position of equilibrium be at o, then the resistance of the pump brake may be represented by ordinates to the curved line. At a the resistance of the fluid is nothing, and the initial acceleration of the ball will, therefore, not be affected by it, and it can cause no periods of rest, and is for this reason preferable to sliding friction, but that it cannot entirely take the place of sliding friction will be made clear by the following argument: The energy absorbed by the pump brake is equal to the mean resistance multiplied by the displacement, and the mean resistance can without appreciable error be taken as proportional to the square of the mean velocity, and the mean velocity is very nearly proportional to the amplitude of the oscillation; that is, mean resistance of the pump brake is nearly proportional to the square of the amplitude. If, therefore, in Fig. 20 the amplitude is measured from along the base line, and the mean resistance is represented by corresponding ordinates, for instance, $e\ f$ represents the mean resistance for amplitude $a\ e$, then the mean resistance for a series of gradually increasing amplitudes would be represented by ordinates to a curve as shown in the figure. The equation of this curve is $y = k\ x^2$, and it must, therefore, be tangent to the base line at a. The mean magnitude of resistance needed, being directly proportional to the amplitude, can be represented by ordinates to a straight slanting line starting at a, for instance, the line $a\ h$, and it is, therefore, evident that the resistance of the pump brake would in this case be inadequate for oscillations smaller than $a\ e$, and if we increase the resistance of the pump brake there will still be a lower limit for the oscillation below which the resistance would be insufficient; that is, the slow motion of the governor ball by small oscillations will make the pump brake ineffective for such oscillations, and a small amount of sliding friction will, therefore, in any case be needed. I have not taken into consideration the friction between the piston of the pump brake and the cylinder wall, which in some shaft governors may be quite considerable, unless the cylinder is radially disposed in relation to the center of rotation, for otherwise the piston will, under the action of centrifugal force, exert a pressure on the cylinder wall, which, by high speed, may amount to over 50 pounds, and in such cases the sliding friction thus produced would be sufficient for stability. The fluid most generally used is oil or glycerine, but air will do well enough if larger pistons are used and friction avoided.

Referring to Fig. 20, it will be seen that the curve of mean resistance rises rapidly for larger oscillations, and such resistance may prevent a sufficiently quick action of the governor, and thereby increase the instantaneous variation in speed beyond admissible limits. This will be the case when the opening through which the fluid escapes is made too small; and thus it appears that there is a practical limit to the resistance

which may advantageously be got from a pump brake, and that if nearly all friction was eliminated from the governor system the pump brake could not supply the deficiency, and the governor weights would consequently be continually oscillating within the limits imposed by the pump brake. If, for instance, the mean resistance for different amplitudes be represented by the curved line in Fig. 20, the extent of such oscillation would be represented by the distance $a\ e$. Fluid resistance will cause no intervals of rest, but it will retard the motion of the ball and thus cause an increased instantaneous variation in speed and a consequent increase of force y_1; the retarding action of the pump brake is, therefore, nothing but a necessary evil. But it is sometimes stated in works on the steam engine that the dash pot will prevent the governor from acting "too sudden" or "too quickly," etc. Such statements are misleading, and show an incorrect conception of the principles of stability, for the quicker the action of the governor the better the regulation in every respect. I shall in the next article explain how the action of the governor may be quickened by reducing the inertia, and thus in many cases stability may be obtained without a pump brake, or the resistance may be reduced considerably, and thus the most serious objection to the pump brake will disappear.

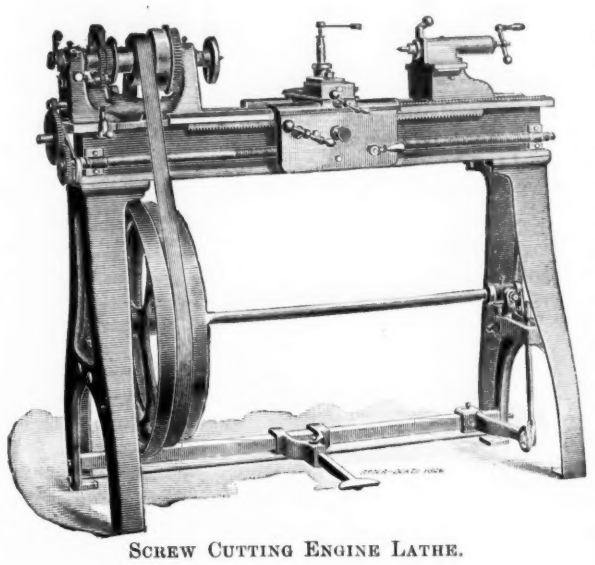
It has probably sometimes occurred to the designer that a pump brake might steady the action of an isochronous governor. It would certainly prevent it from acting "too quickly," but it would probably aggravate the unavoidable evil of instability by magnifying the fluctuation in speed. I have shown that the pump brake will be ineffective for small oscillations, and this would, in fact, settle the question of the utility of the pump brake for an isochronous governor, but I shall now show that the oscillation of an isochronous governor cannot be confined within any definite limits by the pump brake. In Fig. 22, let the ball move from a to b, o being the position of equilibrium, and let the curve marked y_1 be the boundary line of force y_1; this curve must be perpendicular to the base line at a and b, as was shown in the last article. Let the resistance of the fluid be denoted by y_2, and be represented by a curve as shown in the figure. In the case of isochronism force $y_0 = o$, and we have, therefore, as a limiting condition of stability that area y_2 shall be equal to area y_1. The effective force is now represented by the area between the curves, and the first part of curve y_2 must, of course, be below curve y_1, for otherwise no motion would take place, and curve y_2 must therefore necessarily intersect curve y_1 at some point, for instance, at i. From the fact that force y_2 varies as velocity squared, it follows that curve y_2 must be horizontal at the point of intersection, and it also follows that when the two curves become parallel, as, for instance, at p, there must be an inversion of curvature of y_2. From these considerations it becomes evident that there can only be one intersection of the curves, if any, and that curve y_2 must obtain a concave curvature before it reaches the point b, and, as this is impossible without a second intersection, it follows that no intersection of the curves can take place. Area y_2 can, therefore, not be equal to area y_1, and the oscillation would consequently be increasing, the governor would race. This is an elementary demonstration applied to a special case, but it can probably be shown that a reciprocating force of some kind is necessary for the stability of any dynamical system, although I am not aware that this theorem has been pronounced and established in its most general form.

If air is used in the pump brake instead of a liquid, the elasticity of the air will furnish a reciprocating force, which, under favorable circumstances, would be sufficient to prevent violent racing, but it would, on account of the hyperbolic curve of elasticity, become ineffective by small oscillations. A further study of the influence of a pump brake on the action of the governor would be of interest to mathematicians, but it does not admit of an elementary treatment, and I doubt that it would be of sufficient interest to engineers to warrant its appearance here.

I have preferably used elementary demonstrations because I think a clearer conception and broader views can be obtained thereby than by a purely mathematical discussion; but I should never allow myself to make positive statements if I had not submitted the whole matter to the test of pure mathematics; for a mathematical investigation establishes a fact where otherwise we may have an inference or a prob ability only.

In my next article I shall discuss the influence of inertia, which is one of the most important and most interesting subjects in the theory of governors.

Eleven-Inch Screw Cutting Engine Lathe.



SCREW CUTTING ENGINE LATHE.

The accompanying illustration is of an engine lathe which is built for either foot or other power, swings 11 inches over the bed, and 24 inches between centers, with bed 4 feet long, as shown.

The cone pulleys are for a 1¾-inch belt, the largest step of the spindle cone being 6 inches diameter.

The spindle has a $\frac{7}{16}$-inch hole through it. The feed is by gears driving a screw, the threads of this screw not being used, however, except for screw cutting: the regular feed being by friction driven from a spline cut in the screw.

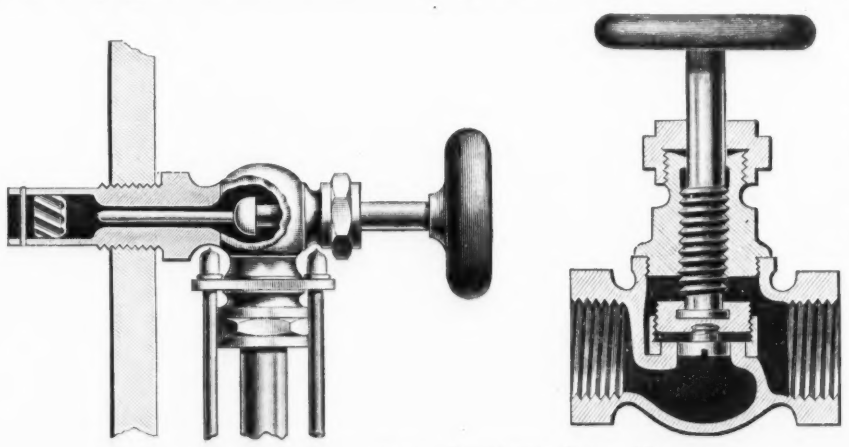
In the head there is a reverse mechanism for the screw which does away with the necessity for reversing the lathe in screw cutting, whether driven by treadle or power. The cross-slide will face the entire swing of the lathe. The foot-stock is held to the bed by an eccentric.

All the gears are cut; screws and rack are steel. Gears are furnished to cut screws of all integral pitches from 4 to 16 inclusive, beyond which number 18, 20, 22, 24, 26, 28, 30, 32, 36 and 40 are cut.

When desired the lathe is furnished with countershaft for power. The lathe weighs about 550 pounds. It is made by Chas. A. Mann, 166 Doyle Ave., Providence, R. I.

Improved Safety Gauge Cock—Improved Globe Valve.

In previous issues we have explained the features of gauge cocks and valves for water glasses having the valve so arranged as to be automatically seated by pressure and forced inward off its seat by the stem, the valve proper being an independent piece and provided with outward spiral grooves, through which the steam and water pass to the atmosphere, thus producing a rapid, rotary motion of the valve, tending to make it clean itself and to grind the seat slightly every time it is closed.



IMPROVED SAFETY GAUGE COCK—IMPROVED GLOBE VALVE.

This form of valve has now, by a slight modification, been so made as to very much reduce the danger of scalding when the valve or cock becomes in any way broken off outside the boiler, as frequently happens in the case of locomotive wrecks.

The change consists simply in extending the inner portion of the valve beyond the thread and so as to bring the valve seat within the boiler shell, the result being that if the valve or cock is broken off outside the boiler, the valve immediately seats by the pressure, and no escape of steam or scalding takes place.

The second engraving is of a globe valve which has an improved form of disk, held in place by a screw passing through its center, and by a cap threaded to the outer portion of the metallic disk, as shown; thus exposing the composition disk only as much as is necessary to cover the seat; holding it very securely in place, and by the projecting metal about it, protecting it when wide open from the scoring action of the steam or water.

These improvements are manufactured by Frank M. Ashley, 136 Liberty street, New York.

Behavior of Rubber Springs.

BY HARRIS TABOR.

The law of flexure in steel springs, and, in fact, all springs which undergo compression and extension without change of sectional area is well known. The shape of the spring has no influence so long as the whole spring is free, that is, subject to flexure without other resistance than its own elasticity. If we take the spring balance scales, an indicator spring or the old Salter spring balance safety valve we find that a given resistance to such springs at any point in their free extension or compression will exert like influence; if we add, successively, equal weights to such springs, each weight will extend the spring a like amount, hence we know the law of resistance to springs, which do not change their sectional area under tension, is arithmetical.

There is a class of springs which give elasticity in the direction of extension and compression rather than flexure, and such springs change their sectional area in proportion to the tension they are subjected to. These springs are governed by a different law. Gutta percha is the best representative type of this class. If we take a stationer's ordinary rubber band and suspend by it a weight (Fig. 1) it will extend a given distance, say $\frac{5}{8}$"; if we add another equal weight there will be a further extension of $1\frac{1}{8}$" instead of $\frac{5}{8}$", and if we add the third weight it will give an increase in length of $2\frac{1}{4}$" — $3\frac{3}{8}$ the extension produced by the first weight. If a careful measurement of a section of the band had been made before the weights placed the band under tension, and similar measurements made after the weights were suspended, it would be seen that the sectional area decreased and the spring became relatively weaker in proportion to its extension, and this without reaching the limit of elasticity. In fact such a band may be extended five times its length without reaching elastic limit. When rubber is treated as a compression spring its scale increases with compression for the reason that its sectional area increases. This increase in sectional area, when the spring is compressed, is so great that a rubber spring buffer, such as are used under cars, soon becomes a solid block Fig. 2 shows a rubber spring with and without load (dotted lines show compression) and illustrates this tendency to enlarge area of section.

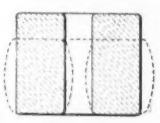


Fig. 2

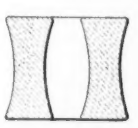


Fig. 3

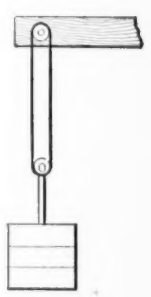


Fig. 1
American Machinist

The theoretical rubber spring for compression would probably call for reduced middle section, enlarging towards the ends, like Fig. 3. Such springs in extension would call for smaller ends enlarging towards the middle. It is possible that rubber shapes may be so proportioned that springs may be made which will scale with the same ratio that governs steel springs.

Notes on Belting*.

BY FRED W. TAYLOR.

The problems in belting, while apparently at first sight so simple, are in reality so complicated, and so many considerations must be entertained in their solution, that most of us find ourselves continually forming new conclusions on the subject and revising old ones. The notes contained in this paper are offered not as a strictly logical and systematic treatise, but with a wish to present for discussion some rather disconnected conclusions arrived at from practical rather than theoretical considerations.

It would appear from a study of the best experiments and articles on belting, from which the rules and tables in common use have been deduced, that the chief consideration has been how to get the maximum of work from belting; while, in making up belting tables, the two most important considerations—how to secure the minimum of interruptions to manufacture, and the maximum of durability—have not hitherto received due attention. The one consideration which should have more weight than all others in making up tables and rules for the use and care of belting is how to secure the least possible interruption to manufacture from this source.

It is the writer's judgment that belts should be made heavier and run more slowly than theory and accepted rules would indicate, not only for the sake of reducing the belt bill in the long run, but even more to avoid the frequent interruptions to manu-

*Abstract of a paper presented at the New York meeting of the A. S. M. E., December, 1893.

facture. In figuring the total expense of belting, and the manufacturing cost chargeable to this account, I think that most careful observers soon come to the conclusion that by far the largest item in this account is the time lost on the machines while belts are being relaced and repaired. This is certainly the case even where the process of manufacture is such that any one machine can be stopped without affecting the running of its neighbors, but far more so in those establishments where the running of a series of machines is dependent one upon another, and the stoppage of one machine involves delays on others.

A NINE YEARS' EXPERIMENT ON BELTING.*

While working as foreman of a machine shop, the tools of which were frequently driven to their maximum capacity, the writer became convinced that the belts, which were laced according to the ordinary rules, were a great source of loss to the company—not so much from the cost of the belting and the labor of lacing as from the incidental delays to the machines, and the diminished output of the shop resulting therefrom. This was particularly emphasized when piece-work rates were established, requiring the machines to be driven hard and continuously. The belting was then shown to be by far the largest source of trouble in the shop.

In looking into the experiments that had been made and the articles that had been written on belting up to this time, it was found that all carefully conducted and recorded experiments were of short duration, their chief object being the determination of the coefficient of friction. But of equal importance in formulating rules for belting is the knowledge of what tension can be surely maintained through a term of months, or what elements chiefly affect the durability of belting; yet these considerations appear to have been rather neglected by experimenters. Very little information could be obtained either as to the cost of maintenance of belts, or in regard to the interruptions to manufacture from belting, when used under known and uniform conditions as to tension and general treatment.

Believing that reliable information on these points could only be obtained by means of an experiment lasting through a term of years, the writer was fortunate in having the opportunity of making a trial of this sort; and although at the end of nine years the experiment is not finished, still it has proceeded far enough to enable him to form conclusions which are interesting and, it is believed, useful.

In 1883 and 1884 the writer superintended the design and erection of a new machine shop, in which many of the machines from the old shop were used.

As a result of experience in the old shop, the tight and loose pulleys on the countershafts were made much larger in diameter and of wider face, so that the belt power from main line to countershafting was made about two and one-half times as great as formerly. All belts were made endless by splicing, gluing and pegging, instead of lacing or hooking, and *double belts* were used throughout the shop.

It was found impracticable in most cases to alter the driving pulleys from the countershaft to the machine, since generally cone pulleys were used.

In all cases the countershafts were mounted on independent frames, which could be raised and lowered in tightening the belts by the interposition of wooden packing pieces of varying thickness between the frames and the supporting stringers overhead. For this purpose standard packing pieces, varying by eighths of an inch in thickness, were always kept in the tool room. With this method of tightening it was seldom necessary to resplice a belt since six to ten inches of stretch could be taken up in the belt, by gradually raising the countershaft, before resplicing became necessary.

Belt clamps were used having spring balances between the two pairs of clamps, so that the exact tension to which the belt was subjected was accurately weighed when the belt was first put on, and each time it was tightened.

Experience soon demonstrated about the length of time that each belt would run without requiring to be tightened, and at approximately regular periods the spring-balance belt clamps were put on to each belt and the tension of same weighed, and the countershaft raised just enough to maintain the belt at its proper tension. For this reason, it was a matter of very rare occurrence that a belt slipped during working hours. And as the belts were generally tightened on Sundays (the shop working night and day), the minimum of delay was caused on the machines from this source.

In case a belt slipped while the machine was in use, the man running it was never allowed to take it up. It was reported to the foreman, and one man—as far as possible—took care of all the belts. He received his orders from and made his returns in writing to the machine shop clerk, concerning time and materials used, tension of the belts, kind and condition of the splices, and nature of repairs made.

The tension under which each belt was spliced was carefully figured so as to place it under an initial strain—while the belt was at rest immediately after tightening—of 71 pounds per inch of width of double belts.

At intervals of about three months for the first two years of the test, and after this time at intervals of about five months, each belt was scraped clean, and greased with the kind of dubbing recommended by the maker of the belt.

An accurate account was kept of the original cost of each belt, and every item of expenditure, both for labor and materials used in the maintenance and care of same; also the exact stretch of each belt was recorded, and its method of treatment throughout. . . .

The writer in this paper frequently uses the expression, "the ordinary rules of belting." A glance at "The Use of Belting," a book in which Mr. John H. Cooper has carefully compiled all of the belting rules established by the best authorities abroad and in this country, shows us that these rules present a wide range of difference, the ratio of divergence between the lightest and heaviest rules being as 1 to 4. By the expression "the ordinary rules of belting," we refer to a mean of these various rules, which gives a double belt a pulling power of 65 pounds per inch of width, and places the most economical belt speed at between 5,000 and 6,000 feet per minute.

In reading articles on belting, we note that there seems to be no uniformity in the use of terms to express the tension under which belts are tightened, and the loads to which they are subjected while running. We therefore think it advisable to define the meaning which we attach to certain terms.

When pulleys upon which belts are tightened are at rest, both strands of the belt (the upper and lower) are under the same stress per inch of width. By "tension," "initial tension," or "tension while at rest," we mean the stress per inch of width, or square inch of section, to which one of the strands of the belt is tightened, when at rest. After the belts are in motion and transmitting power, the stress on the slack side, or strand, of the belt becomes less, while that on the tight side—or the side which does the pulling—becomes greater, than when the belt was at rest. By the term "total load," we mean the total stress per inch of width, or square inch of section, on the tight side of belt while in motion.

The difference between the stress on the tight side of the belt and its slack side, while in motion, represents the effective force or pull which is transmitted from one pulley to another. By the terms "working load," "net working load," or "effective pull," we mean the difference in the tension of the tight and slack sides of the belt per inch of width, or square inch section, while in motion, or the net effective force that is transmitted from one pulley to another per inch of width or square inch of section.

In examining the summary of the following table,* please bear in mind that shifting belts were so used as to be subject to a net working load only $\frac{4}{10}$ as great as that of the cone belts. Each style of belt was, however, tightened repeatedly to the same tension, 71 pounds per inch of width. All belts were double leather.

The cone belts were *supposed* to give an effective pull on the pulley of 65 pounds per inch of width, and the shifting belts 26 pounds.

Originally about fifty belts were started in this experiment, but only forty-two were found available for making up the averages given beneath.

The shifting belts vary in dimensions from 39 feet 7 inches long, 3.5 inches wide, .25 inch thick, to 51 feet 5 inches long, 6 5 inches wide, .37 inch thick. Cone belts vary in dimensions from 24 feet 7 inches long, 2 inches wide, .25 inch thick, to 31 feet 10 inches long, 4 inches wide, .37 inch thick.

The shifting belts vary in speed from 565 feet per minute to 1,570 feet per minute. Cone belts vary in speed from 225 feet per minute to 1,340 feet per minute. . . .

It is interesting to note that after 8.8 years of life the total cost of maintenance and repairs of the shifting belts amounts to only 30.4 per cent. of the original cost, while with the cone belts the maintenance and repairs through a life of 6.7 years amounts to one and one half times the first cost.

In the writer's judgment, by far the greatest point of advantage of the shifting belts lies in the fact that the interruptions to manufacture are nearly seven times as frequent with the cone as with the shifting belts, each shifting belt having been tightened or repaired on an average only 6.6 times during nine years, while the cone belts averaged 32 interruptions to manufacture in 6.7 years; the shifting belts having run on an average twenty-two months without tightening, while the cone belts ran only two and one-half months. . . .

In the writer's judgment, by far the most important matter to be determined is the reason why the shifting belts have proved themselves so much more satisfactory than the cone, and with this end in view it may be well to recapitulate the various elements which chiefly affect the life and satisfactory running of belting. They were, he believes, as follows:

(1) The material from which the belts are made and the method of their construction.

(2) The means of fastening and tightening them on the pulleys, *i. e.*, whether laced, spliced, or fastened with hooks.

(3) The care and regularity with which they are greased, and whether they are kept clean and free from machinery oil.

(4) The general nature of the service which the belts are called upon to perform.

(5) Whether the belts run vertically or horizontally.

(6) The relative length of the belts.

(7) The relative speed.

(8) The tension under which they were tightened.

(9) The average total load to which they are subjected while working.

Since the "shifting" and "cone" belts were made by the same makers and of the same materials, and were spliced on the pulleys and greased and treated in exactly the same way, we need not consider the first three elements as given above.

As to the fourth—"the general nature of the service of the belts"—I think that to be used on either tight and loose pulleys or cone pulleys is about as severe a duty as belts are called upon to perform. It would be difficult to say, however, which of the two duties is the harder on belting, so that I do not think that we can look here for an answer to the question.

Undoubtedly, horizontal belts will run under a lower tension than vertical, and in this respect the service of the cone belts was rather more severe than that of the others.

It will be remembered, however, that when the machines were moved from the old shop to the new one in which this experiment was made, the tight and loose pulleys on the countershafts were all thrown away and far larger ones substituted for them. This was done because the shifting belts in the old shop were such a great source of trouble. They were there run under the same "total load" as the cone belts, and owing to their inaccessibility undoubtedly wasted more time than the others. It would appear, therefore, that the direction in which the belts run does not seriously affect their durability.

In the sixth element—"the length of the belts"—the shifting belts unquestionably have an advantage, since they are one half longer than the cone belts; and it is safe to say that (other things being equal) the life of the belt should be greater as the belt increases in length, up to, say, 50 feet. The small difference in the length of the belts, however, would not at all account for the great superiority of the shifting belts, and this advantage, it would seem, must be much more than overbalanced by the fact that the shifting belts ran about twice as fast as the cone belts, and were always running when the main line of shafting was moving. The fact that the shifting belts ran about twice as fast as the cone belts, and yet lasted so much longer and worked in every way so much more satisfactorily, shows that the relative speed of belts (at moderate speeds at any rate) has but little effect on their durability.

It is, however, without doubt, in elements 8 and 9 that we find the answer to our question, for while the two classes of belts were repeatedly tightened to the same initial tension, 71 pounds per inch of width, or 239 pounds per square inch section, the shifting belts were, owing to their greater speed and width, subjected to a far lighter total load than their competitors, and to this fact their great superiority over the cone belts is undoubtedly due.

The good effects of the lower "total load" to which the shifting belts were subjected can be clearly traced through several items in the table. The most important of these would seem to be item 48, showing the tension to which the belts had fallen when they required tightening.

The averages in this item* (for the cone belts especially) show the exact point in the tension of the belts at which they were just able to do the work required of them, and it will be remembered that this point was in no way arbitrarily determined, but was fixed by each belt for itself by giving indications that it was about to slip seriously. It should be noted that in the case of the shifting belts they rarely, if ever, slipped.

They were taken up, in almost every case, because they had stretched so much that they began to flop and jump about to such an extent as to be in danger of damaging themselves.

In examining items 46, 48, and 56, we note that it only took two and one-half months for the cone belts to fall from the initial tension of 71 pounds per square inch of width to 33 pounds, their slipping point, while the shifting belts were 22 months in falling from 71 pounds to a tension of 21 pounds; and undoubtedly, if the cone belts had been subjected to as light a total load as their competitors, they would have run equally long without requiring to be tightened. Another good effect of the light "total load" on the shifting belts is seen in items 57 and 58, as they stretched $\frac{81}{100}$ of one per cent. before having to be tightened,

*This experiment was made in the machine shop of the Midvale Steel Co., of Philadelphia, beginning in 1884 and lasting until 1893. During the first six years the experiment was under the direction of the writer, while he successively occupied the position of foreman of machine shop, master mechanic, head of the drafting-room, and chief engineer, after which time it was carefully conducted by his successor.

*[For lack of space we do not give the table, and it is not needed, as the conclusions given are fairly drawn from it, and give what belt users want to know.—ED.]

* The writer did not appreciate the importance of this item when the experiment started. It was entered on the records merely as a matter of interest and without regard to its usefulness.

while the cone belts, which were subject to twice as great a total load, required tightening after they had stretched $\frac{4.7}{100}$ of one per cent.

Summarizing the above, we may state that the total life of belting, cost of maintenance and repairs, and the interruptions to manufacture caused by belts, are dependent upon (1) the "total load" to which they are subjected, more than upon any other condition; and that, in our judgment, the other conditions chiefly affecting the durability of belting are:

(2) Whether the belts are spliced, or fastened with lacing or belt hooks.

(3) Whether they are properly greased and kept clean and free from machinery oil.

(4) The speed at which they are run.

Having demonstrated the fact that the life, cost of maintenance, and the interruptions to manufacture are chiefly dependent upon the average total load to which belts are subjected, it becomes of the utmost importance for us to determine the maximum average "total load" per inch of width of belt compatible with economy.

Before entering into the discussion of this matter, the writer wishes to state that he knows of no way in which this problem can be solved with absolute certainty. The conclusions finally arrived at are dependent upon so many conditions that while they appear to be close to the truth, he holds himself ready to again modify his views on this subject, as he has several times in the past. One thing, however, is proved beyond a doubt by these experiments, namely, that the ordinary rules place belting under entirely too severe a "total load."

Probably the most accurate way of arriving at the average strain to which the belting was subjected would have been a series of dynamometer tests on the machines. This, however, the writer has had no opportunity of making.

It would seem as though the effective pull of the belt on the rim of the pulley might be calculated by considering the tension of the cone belts at the time when they required tightening, in connection with their co-efficient of friction, and the well-known belt formulæ.

However, in looking through the careful experiments to determine the co-efficent of friction made by General Morin; Messrs. Briggs and Towne, of the Yale & Towne Manufacturing Co., Conn.; Messrs. Wilfred Lewis and J. S. Bancroft, for William Sellers & Co., of Philadelphia; Prof. G. Lanza, of the Massachusetts Institute of Technology, and Mr. Edward Sawyer, of Boston, we see that the co-efficient of friction varies from 15 per cent. to 135 per cent., according to the nature and condition of pulleys and belts, the belt dressing, the amount of slip, and even the atmospheric conditions.

And, again, the notable discovery of Messrs. Lewis and Bancroft (whose experiments, on the whole, appear to be the most carefully and thoroughly conducted), that the "sum of the tensions on both sides of the belt does not remain constant," upsets all previous theoretical belting formulæ.

When we consider these facts, it would seem doubtful whether any calculation on the subject would lead to reliable results. . . .

In estimating the average tension in pounds per inch of width, as given in 52, we have concluded that since it required only two and one half months for the cone belts to fall in tension from 71 pounds to 33 pounds, therefore the fall in the tension of the shifting belts from 71 pounds until the tension was in the neighborhood of 33 pounds must also have been rapid. We note, however, that it required twenty-two months for the shifting belts to fall in tension from 71 pounds to 22 pounds. It is safe to say, therefore, that during the greater part of this twenty-two months the tension of the shifting belts must have been below 33 pounds, and approaching, during this time, more and more slowly the lower limit of 21 pounds.

On drawing a curve which approximately represents the fall in tension corresponding to the months of service, the average tension of shifting belts was seen to be about 28 pounds per inch of width, while the corresponding figure for cone belts was believed to be about 46 pounds.

Adding together the net working load and the average tension we arrive at the "average total load" on the belts, 54 pounds per inch of width with shifting, and 111 pounds with cone, belts.

The various authorities which the writer has studied place the safe total load of belting per square inch of section at from 290 to 500 pounds per square inch of section. Generally speaking these authorities base their total load upon the tensile strength of leather, taking an arbitrary percentage of this tensile strength as their safe load. So far as I know they give no reason why they choose this particular fraction of the breaking strength as their safe load, and therefore their conclusions seem arbitrary and unsatisfactory.

Since the shifting belts have proved themselves so much more economical than their competitors, and since their economy is due to their lower "total load," we see from items 54 and 55, that a total load of 111 pounds per inch of width, or 358 pounds per square inch section of belts, is too great for economy; 54 pounds per inch width, or 174 pounds per square inch section, being far more economical and satisfactory.

Evidently then the most economical total load for belting must lie between 174 pounds and 357 pounds per square inch of section of belt. . . .*

The writer has recently had a most unfortunate but interesting opportunity of comparing the ordinary rules for belting with the above rules.

For three years past he has been engaged as general manager of a company in building and organizing two large sulphite pulp mills, in which about 3,500 horse power is transmitted by belting, this power being transmitted in units varying from 1,000 horse power to a belt down to a few horse-power per belt. The shafting runs night and day throughout the week from Sunday to Sunday, without a shut down. Through a misunderstanding during the absence of the writer at one of the mills, one half of the other mill, aggregating about 900 horse-power, was belted under the following rule, which is believed to be about an average of the ordinary belting practice:

"A double leather belt, or six- to seven-ply rubber belt, will transmit 65 pounds pull per inch of width to the rim of the pulley."

The speed of the belting was from 5,000 feet to 6,000 feet per minute.

About one-third of the belting in the mill was leather, and two thirds rubber.

On the return of the writer to the mill the second half of the mill was belted on the basis of 30 pounds pull per inch of width of double belt transmitted to the pulley, and a belt speed of 4,000 to 4,500 feet per minute.

It is safe to say that the belting of the first half of this mill (ordinary rule) gave one hundred times as much trouble as that of the second half. In fact the belting proved to be the chief source of trouble and expense in running the first half of the mill, owing to the frequent interruptions to manufacture caused by it; while that of the second half ran from the start with almost no trouble.

This has proved to be a most emphatic though expensive confirmation of the results of the nine years' experiment above described. . . .

The writer has adopted a speed of from 4,000 to 4,500 feet per minute as the most economical belt speed for several reasons, one of which is that belting running above this speed has a great tendency to run in waves on the slack side, and flop about and oscillate from side to side of the pulleys, and so cause rapid wear, this tendency being greater and more dangerous as the width of the belt with relation to its thickness increases.

The principal reason for adopting this speed, however, is that when the centrifugal force is taken into consideration, a total load of from 200 to 225 pounds per square inch section gives a maximum of efficiency when the belt runs at 4,000 to 4,500 feet per minute.

In this connection I wish to call attention to the remarkable formula, developed by Mr. Wilfred Lewis for determining the maximum economical speed of belting corresponding to given total load.

The writer regards this as one of the few valuable belting formulæ deduced exclusively from theoretical considerations, and as its value appears to have been rather overlooked, he takes the liberty of quoting from Messrs. Lewis & Bancroft's experiments, made for William Sellers & Co., as follows:

"V = velocity of belt in feet per second.
S = working strength of leather in pounds per square inch.

"The velocity at which the maximum amount of power can be transmitted by any given belt is independent of its arc of contact and co efficient of friction, and depends only upon the working strength of the material and its specific gravity.

"From equation we obtain for the maximum power of leather belts the condition:

$$V = \sqrt{28\,S};$$

and for any other material whose specific gravity is y, we find

$$V = 5\sqrt{\frac{S}{y}}."$$

If we insert in the above formula the total load of 200 pounds, which the writer believes to be most economical load, we have 4,500 feet as the speed of maximum efficiency of the belt. . . .

(To be Continued.)

* A total load of 174 pounds is evidently lighter than is required for economy, since an examination of the records of the shifting belts shows that they ran on an average 22 months without requiring tightening, and that even at the end of this time they did not often slip on the pulleys, but were generally tightened on account of their flop.

LETTERS FROM PRACTICAL MEN.

Piston Packing Rings.

Editor American Machinist:

The letter, headed as above, in your issue of December 14, 1893, from one of your oldest and ablest correspondents, demands that I shall at least answer his question.

He ("Bell Crank") asks why I do not distribute the metal in my rings to produce the required stiffness instead of securing the required elasticity by deflection. In other words, he wants to know why I do not make my rings eccentric. "Bell Crank" has answered this question in part in the last paragraph but one of his letter, by saying: "I am aware there are a number of good mechanics who use the parallel ring and think it just as good as any other shape." I believe the "number" he speaks of is larger than the number of good mechanics who do not use the parallel ring, and I have not the presumption to suppose the majority of our mechanics are doing a foolish thing. Apropos I quote from "Modern Locomotive Construction," appearing in the AMERICAN MACHINIST, June 11, 1887. "But from the writer's experience and upon careful inquiry, he is led to believe that rings of uniform depth throughout, as shown in Fig. 216, will give as good satisfaction as that shown in Fig. 217." (Fig. 217 is slightly eccentric.)

Fig. 12

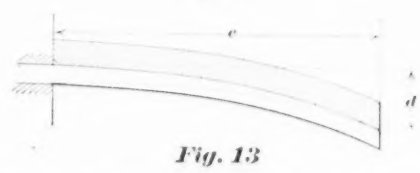


Fig. 13

Giving my own experience in this line I will say that I have made and used and given as fair a trial as I knew how, to at least 100 eccentric rings in cylinders from 6″ to 36″ diameter in the ten years previous to reading "Modern Locomotive Construction." I could find no advantages by their use, on the contrary they were objectionable on account of not wearing the groove in the piston parallel, neither would they remain of parallel width. If anything the eccentric ring is more liable to break than parallel rings are, and are also capable of doing more damage when they do break than the other variety. By my system I can make eccentric rings that will fit a circle as perfectly as the parallel ring can be made to do, but I do not think there would be any appreciable advantage to be gained by so doing, while there are objections, even if they are of no great moment.

The cut accompanying "Bell Crank's" letter is not proportioned in harmony with his figures. It should be as I have shown in Fig. 12, which is accurately full size for a 2″ cylinder, or ¼ size for a 16″ cylinder, etc. Suppose we proportion a 16″ ring from the figures "Bell Crank" gives. The thickness of the ring opposite the cut will be $8 \times .06 = .48''$. At 10 degrees from the cut it will be $.48 \times .197 = .0945''$. Less than .1″ may appear pretty thin for a 16″ ring at 10 degrees back from the cut, but it is still over three times too thick to form a perfect circle under deflection. I have made 16″ rings as thin as ¼″ at the cut. I am sure that less than that is impracticable. When making eccentric rings my practice was to make the part at the cut one-half the thickness of that opposite to it.

The formula given by "Bell Crank" for determining the thickness of the ring is O. K. and ought to be (with some slight modification) adopted as a standard for square parallel rings. The modification I speak of would be to decrease the constant (.06) gradually for rings above 20″ diameter in order to make allowance for this increased width and preserve more nearly a uniform radial pressure, which "Bell Crank" says should be 14 pounds per square inch when the ring is new. If "Bell Crank" will "strike an average" between the thinness of his rings at the cut and the thickness of his pressure and divide it by 2, he will have both nearer right. Just how he would have a 16″ ring stand up under a load of 224 pounds he has failed to mention. The youngest apprentice who reads the AMERICAN MACHINIST would sooner "attempt to raise water a hundred feet by a simple vacuum" than to expect a 16″ packing ring 1″ wide and ½″ thick opposite the cut to support, by its elasticity, a uniform load of 224 pounds.

As it may be easily and briefly done it will not be amiss to calculate the deflections that such a load will produce in such a ring and then to calculate its strength. As "Bell Crank" says we may assume half the ring to be a beam fixed at one end and uniformly loaded as is shown in Fig. 13. The formula for deflections in such beams and loads is $d = \frac{1}{8}\frac{l^3\ W}{E\ I}$, in which d = deflection in inches, l = length of beam in inches, W = load in pounds, E = modulus of elasticity, I = moment of inertia. We will suppose our ring-beam to be 16″ long, 1″ wide, and 48″ deep. Then $d = \frac{1}{8} \times \frac{16^3 \times 224}{17{,}000{,}000 \times 1 \times \frac{.48^3}{12}}$

$= \frac{1}{8} \times \frac{4{,}096 \times 224}{17{,}000{,}000 \times .009216} = .74''$. The other half ring would deflect as much more, so we shall have a spring at the cut of nearly 1½″. Then as "Bell Crank" makes an eccentric ring we must taper our beam as shown by the dotted line in Fig. 13. A beam so shaped will support the same load as a parallel beam, but the deflection will be twice as great, or nearly 3″ for a double

beam. This, of course, is too much by about 4 times. To determine the strength of a beam shown in Fig. 13 the formula is $W = \frac{2\,K\,b\,h^2}{l}$, in which W = the weight the beam will support with safety, K = coefficient for cast-iron = 150, b = breadth of beam in inches, h = height of beam in inches, l = length of beam in feet. Thus $\frac{2 \times 150 \times 1 \times .48^2}{1.33} = 52$ pounds. This is a safe load and is about one-fourth the ultimate breaking load. It is also less than one-fourth the load "Bell Crank" recommends. I think 25 pounds total load on a parallel ring 16″ diameter, ½″ square, will be found ample to make it steam-tight, especially if its surfaces are ground smooth and true as they are by my method of manufacture.

I am glad to have your readers criticise my rings, but I hope they will in the future confine themselves to the discussion of facts, rather than expressing their opinions *as* facts, or that they furnish ample proof that their opinions are well grounded, if facts are not obtainable.

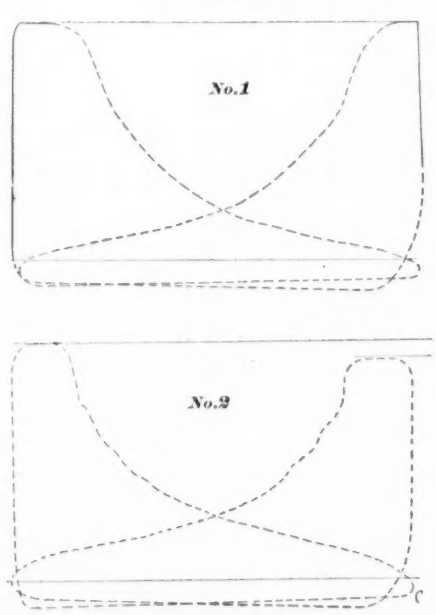
Youngstown, O. J. H. DUNBAR.

When the Coal Gives Out.

Editor American Machinist:

"Where will we get our power when the coal gives out?" has been the theme of many articles and much discussion. While there is no immediate danger of the coal supply, the chief source of light, heat and power, being exhausted, the high price at which it is sold makes us wish we were not at the mercy of a monopoly. As power, light and heat are convertible, it follows that if we had an unlimited amount of power, we could easily produce all the heat and light necessary for our existence; but very little heat compared with that required for manufacturing purposes is required for our health and comfort, and that could easily be furnished had we an abundance of power. There is plenty going to waste in the winds, tides and waterfalls, which will, no doubt, be utilized more or less in the future. Several schemes have been suggested for utilizing the energy of the tides, but we believe that no great amount of power has been obtained in this way. At present part of the Niagara is being harnessed, and will, no doubt, furnish plenty of power to those who can pay for it within a distance of economical transmission. It seems that nature's forces are going to waste for lack of economical ways of controlling them. It has been suggested that when the coal gives out we can utilize the heat of the sun, but the sun is millions of miles away, while within three or four miles from every city in the world there is sufficient heat to furnish all the power needed, and much to spare, while within six miles we could get a temperature of melting lead, and at twenty-five the elements would melt with fervent heat. The direction from these cities would, of course, be toward the center of the earth. Although the temperature increases faster in some parts of the world than in others, the average is about 1° F. for every 50 to 60 feet in depth. The average temperature of such cities as New York, Chicago or Cleveland is about 50° F. The temperature of steam at 100 pounds is about 325° F. or 275° F. hotter than the average temperature on the surface in this latitude. Now, 60 feet × 275 = 16,500 feet, the depth necessary to go to get a temperature of 325°. If we could bore or drill a hole into the earth this depth, we would get sufficient heat from nature to take the place of the coal now used. To utilize this heat we could transmit it to water, and use the steam for power at the surface. By drilling a hole and incasing same with tubing of proper strength, we would have a vertical boiler, say three miles high, of proper diameter for the horse-power required. This boiler would have a temperature at the lower end of 325, at the middle of 200, and would have heating surface about ⅓ of its length, and cooling surface the rest, which, of course, would have to be well insulated. It could be fed from the top, and the water line carried almost anywhere without danger. Such a scheme seems a little chimerical, yet when we contemplate the amount of heat we have every reason to believe exists so short a distance below us, and when we think of the many millions spent each year for fuel to keep the wheels of toil in motion, is it any wonder we should contemplate utilizing these wasting forces? Horizontal tunnels have been drilled through mountains, railroads are built to transmit coal thousands of miles, pipes have been laid to conduct natural oil and gas long distances, yet but a few miles into the earth there are furnaces whose fires never go out, but, were they accessible and controlled, would furnish unlimited wealth to our nation. Whoever attempts to penetrate the bowels of mother earth in quest of the higher temperature, will have a definite and tangible goal, of which he will become more cognizant as he approaches it. If any one were assured that unlimited gold was to be found 20,000 feet below, the writer has no doubt there would be many companies organized for reaching it, even though they had to provide refrigerating apparatus to assist them to obtain such a depth. Yet unlimited heat within our control should be more of an incentive to dig or bore. If, before reaching the depth desired, we should strike gas, oil or a gushing geyser, either would be convertible into the object of our research. There are flowing springs in Montana of a temperature of 212° F. at the surface, and even the most skeptical must believe in the heat below us, but the problem is to utilize it. Great might be the obstacles to overcome, but consider what we would accomplish.

CHAS. ELLIOTTE.



Long vs. Short Connections to Indicator.

Editor American Machinist:

In your issue of December 28th is a letter from "M. E.," who, in commenting on Mr. Willis' experiments, says that it represents, so far as he is aware, the first attempt to defend the use of long and indirect connections.

These long connections have been defended for years, both with theory and experiments; but in most cases where no difference is shown there is so much lead given that the difference would not be shown on the cards, and in others the cards are from engines with high rotative speed, and these, too, generally have *some* lead. The writer at one time had a number of sets of cards from a 28″x60″ engine at 53 revolutions that showed the difference, but gave them away to show those interested.

The writer was met last week with the request that a new cylinder be fitted up with angle valves, pipes, and a three-way cock, and when he remonstrated was met with the statement that no one yet had been able to show any difference between long pipes and valves and short pipes. For a busy man life is too short and time too valuable to go through a long demonstration and fitting up to make experiments with the two types, and so the long pipe man usually gets the best of the argument, and that position becomes intrenched and in time seems impregnable.

With this are tracings from two sets of cards taken from a cylinder 20x48, 57 revolutions, the pipes fitted up so that one indicator could be put on close to the cylinder at each end, and an indicator at a tee in the center as usual with side pipes.

No. 1 is from indicator close to cylinder, and No. 2 from the tee at center of cylinder.

In the original cards, the amount or weight of steam called for in No. 1 is 2,334 pounds, and in No. 2 2,558 pounds. Of course, the engine was taking the same amount in each case. The amount of lead in each will also be noticed.

These cards were taken by Mr. Davis, chief engineer of the Lancaster Mills, and published in the *Manufacturers' Gazette*.

"M. E." is of the opinion that no steam flow occurs in the pipe, but that there is condensation; but condensation would lead to some steam flow to compensate for the condensation. Steam either flows in and out of the pipe or it does not. If it flows there is friction; if not, there is no condensation.

Mr. Willis' experiments may prove that the long pipe is sufficiently accurate for his work on that particular engine, but it alone would be hardly safe for universal application.

An experimentalist fitted up a small vertical engine so that cylinder oils could be tested. It is a very neat and ingenious device, and experiments with it show that it makes very little difference what grade of cylinder oil is used on that particular engine even when the packing rings are set out so as to produce excessive friction.

The writer had charge of a set of engines that were not run under the same conditions as the experimental engine.

An oil agent appeared, as sometimes happens, and he had a straight mineral oil that he would warrant, and wanted to leave a barrel to be paid for on approval. After a trial the oil was not approved and the agent was anxious to have the little experimental engine's record taken as proof that his oil was all that could be asked for. This, however, was not done, and in about a year he came around again and said he had some good compounded oil that was all right. When asked about the experiments that he had attached so much importance to, he said that time had shown them to be of no value. That relying on them had cost his company a great deal of money, lost them custom, and also cost their customers money, and he considered the experiments alluded to of no practical value, but very liable to mislead people.

Some years since the United States paid a large sum of money for experiments that showed that using steam expansively was a fallacy.

At the same time practical Mr. Corliss was putting in automatic engines and taking his pay in fuel saved over non-expansive machines.

There have been many experiments that have brought up interesting points, and show all right in certain localities, or under conditions that then exist, but, being accepted as authority, have cost manufacturers many thousands of dollars.

Their object is to show up lots of humbugs that creep in, but care should be taken that something else that costs more does not take its place.

W. E. CRANE.

Waterbury, Ct.

To Prevent Spontaneous Combustion of Coal.

Editor American Machinist:

Noting in a recent issue of the *Industrial News* an account of an address on the "Spontaneous Combustion of Coal," by C. J. H. Woodbury, would say that I do not at present know what preventive measures are usually adopted, or how far, if any, a plan proposed by myself many years ago is in use. It consisted of channels of rough boards laid among coal or grain when loading boats, like drain tiles on land, serving both for ventilation and, in case of fire, ducts for carrying water to the very core of the mass. Now that light steel pipes may be had, these in about 6-feet lengths might be used, one end of each enlarged for admission of small end of next, to prevent much unalignment, but loose enough to permit vent for air, gas or water at each joint.

J. W. PAYLER.

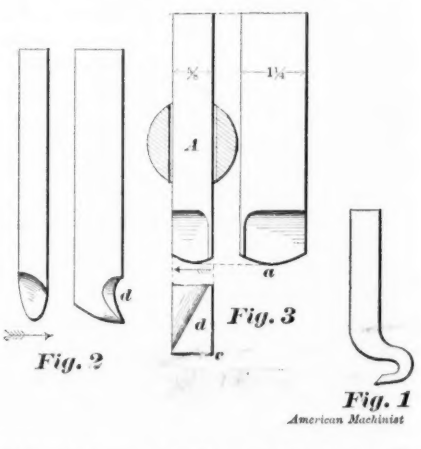
Milling Machine Feeds—Finishing Tools.

Editor American Machinist:

It is doubtful if anything I can say will throw light on the milling machine question now being so fully discussed. I do not believe there is enough in reversing the motion of the cutter to justify the expenditure of much time, or money, in devising means to hold up backlash.

Professor Sweet rightly says, in his contribution of December 21st, that other yielding parts of the ordinary machine will prove troublesome.

It is evident that anything which causes a cutting tool to spring away from its work benefits the finish, especially when the cut is heavy. If the end justified the means, we might about as well advocate reversing the cut on a shaper or planer, by simply turning the tool around, and change the motions of the apron and the bed or ram. We can counteract the downward spring of the tool holder on the planer, by the use of a goose-neck tool like Fig. 1, and so take a



wide or heavy cut without chattering. The principle here involved is clear, we think, to every experienced machinist. It is exemplified in the action of a pencil on a slate, as is sometimes practiced by the idle school boy—when dragged, the pencil will make a smooth line, but when pushed, produces only dots, and makes more noise than marks.

As one contributor has said, "The spindle of a milling machine is the weak link," so we may say of the planer rail, as usually made. The slightest amount of torsion here must affect the quality of the work performed. Hence the necessity of greater width and depth to this piece. The same defect exists in boring-mill rails, but the extension of the boring bar below the saddle subserves the purpose of the goose-necked tool in counteracting the downward spring of the rail and its belongings.

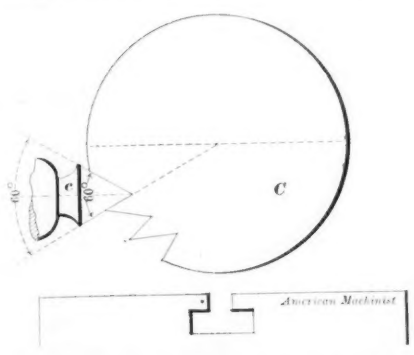
There are many kinds of work which often baffle the machinist's art, when he attempts to prevent chattering, and it is only the careful observer who can apply remedies suited to the various forms of cutters and different kinds of machine tools. A common form of lathe and planer tool is shown in Fig. 2. This tool is shaped to cut in the direction of the arrow, which is proper for a heavy cut, but for finishing, a much smoother cut will be secured by feeding in the opposite direction, especially when used on the shaper or planer. Indeed this principle may be carried further by giving a tool the form shown in Fig. 3, which is strictly a finishing tool, and when properly formed will finish a surface perfectly, even on steel. The edge view *A* is one seen from the front of the machine, and in the case of a planer the tool is fed in the direction of the arrow. To those who have never used this kind of a tool, its action may not be fully comprehended; to such the smoothness of its cut will be surprising. The extreme bearing point *d* should be

flattened nearly straight by the use of an oil stone. Slight clearance is given in the direction of the corner *c*, and in setting the tool the top should be slightly leaned in the direction of the arrow, carrying out the idea suggested by the slate pencil illustration. To get the best results, oil or water must be used with this tool. "QUIRK."

Cutting Spiral Teeth.

Editor American Machinist:

In your issue of January 4th, answer to H. W., Question No. 6, if line of feed motion is at right angles to cutter arbor, the cutter in question could be cut by using a 60 degree end mill as per pencil sketch enclosed herewith, in which *C* is the blank to be cut, and *c* the stem cutter, which as will be seen is so set that one of its sides is on a radial line drawn from the center of the blank. J. M. LYNCH.



Hyde Park, Mass.

What Makes the Holes in the Castings?

Editor American Machinist:

In making cast iron boilers for heating purposes we run the iron about ½ inch thick around a large core which is afterward rapped out. We have recently had much trouble with something like blow holes in the top plates of the boilers. These holes do not usually go all the way through the plates, but are from ½″ to 1″ across and about ¼″ deep, leaving about ¼″ of solid iron between the hole and the core with a very thin film of iron above the holes next the sand in cope. Our cores are dry, and both cores and molds thoroughly vented.

We have made hundreds of these boilers and experienced very little trouble from this cause until lately. Our foundry foreman thinks the trouble is due to the quality of pig iron we are using, and finds many similar holes in the pigs when we break them. But the manufacturers of the iron say that they know of no condition of pig-iron that would cause such defects in our castings.

Now we trust you or your readers to inform us if it is possible for the defects described to arise from the quality of pig-iron we use, or may it come from improper melting or pouring, or must we necessarily look for the cause in our cores or molds?

W. H. DRAKE.

[Some of our readers may be able to give the desired information, in which case we shall be glad to publish it.—ED.]

Strength of Beams.

Editor American Machinist:

In your issue of the 4th, E. D. Mackintosh criticises the general formula, $M = \frac{S\ I}{c}$ in one of its applications, and in doing so falls into one or two errors. In the first place the formula does not assume that the tensile and compressive *strengths* are the same, but that the stress is proportional to the strain throughout the section, or, in other words, that the *elasticity* is the same in tension as in compression, and this, I believe, is found to be approximately the case with most metals used by the engineer.

In the second place Mr. Mackintosh is in error in reasoning from a case of "a single layer of fibers"—which for the assumption to hold good must be *infinitely* thin—to flanges of *finite* thickness, and that to leave out the *web* quite alters the character of the beam, although it does not render the formula inapplicable, as will be seen by a correct application of it.

If we suppose each flange of the beam to be thinned down indefinitely to a single layer of fibers if you like, but its breadth increased so as to keep the areas of the flanges the same and keeping the total depth the same the formula will apply thus

$$W = \frac{8 \times 15{,}000 \times 24.75}{168 \times 4.5} = 3{,}928$$

and $$W = \frac{8 \times 3{,}333.33 \times 24.75}{168 \times 1} = 3{,}928.$$

The moment of inertia being 24.75, and the central gravity at 4.5″ and 1″ respectively from the top and bottom.

Thus we get the equality of strength which E. D. Mackintosh correctly anticipates, and we get it by the application of the formula under discussion.

Again Mr. Mackintosh is in error in stating that the neutral axis is at the middle of the depth of the beam. The neutral axis is that layer of fibers in the depth of the beam that is neutral to tension and compression, the layers on one side of it being subject to tensile force, gradually increasing from 0 to a maximum at the surface of the beam, the layers on the other side being subject in like manner to compressive force, consequently two flanges without a web, if they can be called a "beam," cannot strictly be said to have a neutral axis. They can have a center of gravity though in the extended meaning of the term, and the line through this center of gravity is the one about which to take the moment of inertia.

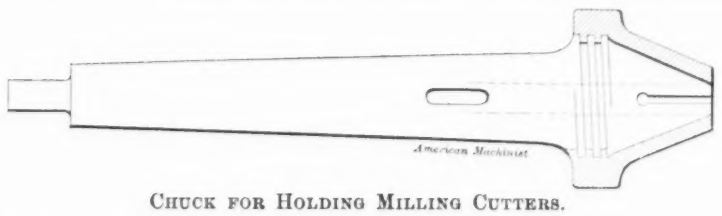
Some of the terms used by Mr. Mackintosh are somewhat misleading. The formula gives not the strengths of the flanges individually, but of the beam as a whole, and the two values obtained are alternative ones, the smaller of the two being the correct one to take, the other in this case involving too high a tensile stress because the two stresses are not called up in proportion to their breaking limits in this particular section of beam. That beam is the more economical in material which has its flanges so proportioned as to give the results of the two equations the same because then the full strengths of the most remote fibers are called up in both tension and compression.

I do not propose to take up more of your space but would suggest, if the above is not sufficient to change the direction in which Mr. Mackintosh sees the formula, that he begin his study of the formula afresh from the beginning, first throwing away all preconceived notions. F. GARSIDE.

Toronto, Ont.

Chuck for Holding Milling Cutters.

Mr. William H. Owen, of the Owen Machine Tool Co., Springfield, O., informs us that he finds a great deal of satisfaction in the use of a chuck for holding stem cutters in the milling machine, which is made about as shown in the accompanying sketch, which shows it as made for the Brown & Sharpe universal machine.



CHUCK FOR HOLDING MILLING CUTTERS.

The shank of this chuck fits the taper hole in the spindle and an enlargement of it just outside the spindle has cut upon it a short square thread. The outer extremity of the chuck is then tapered as shown, and is bored true for the reception of the shanks of the cutters which are cylindrical and flatted at the end to enter the slot at the back for driving. The tapered portion of the chuck is then split in three places as shown and so can be clamped upon the shank of a cutter by tightening the nut upon the outside which has a knurled ring upon it and holes for a spanner wrench, which, however, is seldom or never used, as the hand applied to the knurled collar is ordinarily sufficient to hold the cutter securely.

This certainly makes a very neat arrangement, and amongst its other advantages are that cutters may be made with simple straight shanks, and they are very easily put into the machine or taken from it, the fit of the shanks being such as to enable them to be readily pulled out by the fingers when the nut is loosened. This of itself is a decided advantage over the arrangement which requires that a collet shall first be drifted out of the spindle, and then the cutter drifted out of the collet by another drift. The sketch is not made to scale but shows the principle of construction. It is best to make the square thread clear top and bottom, so that the nut can be centered by the end of the chuck body.

American Manufacturers at Fault.

We find in a recent consular report the following written by James H. Smith, "Commercial Agent," and dated Mayence, September 20, 1893:

"The leading dealer in hardware in Mayence, on whom I called when about preparing my report on packing goods for export, says that he obtains such American articles as he handles from the Hamburg agents of New York export houses, though he has from time to time made direct importations. With respect to the manner in which his goods have always been packed, he has no criticisms to make; but he is very severe in his remarks on the manner in which American manufacturers do business with foreigners. He claims that he has time and time again made efforts to deal directly with American manufacturers, with a view to introducing their goods here; but they turn his letters over to exporting houses—not specialists, but dealing in all kinds of goods—and with such people he does not want to have anything to do. When he writes to a manufacturer and receives his reply through an exporting house, he simply throws the letter into his waste basket without paying any attention to it. What he wants is direct dealing with the manufacturer. The method of business complained of, he claims, works injury to American trade, and is not a course which should be pursued toward such a highly developed industrial and commercial State as Germany. American manufacturers of iron goods and agricultural implements should, he says, if they want to do business in Germany, establish an agency in Germany and put a thorough-going, reliable man in charge of it, and not leave the introduction and sale of their articles to men who handle a most heterogeneous assortment of goods. Only first-class goods should be sent over. He alleges that agricultural implements from the United States have been very much discredited in the past by inferior goods (imitations) being placed on the German market and he intimated that the genuine articles, on account of their price, have not much show beside the counterfeits."

Monthly Meeting of Mechanical Engineers.

DEVELOPMENT OF STATIONARY ENGINES.

The first monthly meeting of mechanical engineers for the discussion of selected topics took place at the rooms of the American Society of Mechanical Engineers, 12 West 31st street, New York, on Wednesday evening, January 10th. There was a very good attendance, and much interest was shown. Mr. M. N. Forney, of the Committee, who has been doing the lion's share of the work in getting things in order and notifying, by mail, more than sixteen hundred members, made a brief opening address in which he referred to the origin of the movement for monthly meetings, detailed briefly the plan it was proposed to follow, and read a number of the many letters that had been received favoring the holding of such meetings.

Mr. C. W. Hunt was then called to the Chair, and the discussion of the following subject entered upon, according to the plan provided one member being called upon to open the discussion, being accorded, for that purpose, and expected to occupy more time than that accorded to members following:

DEVELOPMENT OF STATIONARY ENGINES AS ILLUSTRATED BY THOSE EXHIBITED AT THE COLUMBIAN EXHIBITION IN CHICAGO.

MR. F. F. HEMENWAY—Expression to the effect that very little that was new in the way of steam engines was to be seen at the Columbian Exposition is common amongst steam engineers. Nothing is more natural than this, coming, as it does, from men who are rather intensely interested in knowing what is going on day by day in the world of steam engineering, with the facilities for obtaining information that exist at the present time.

Contemplation of the fact that fifty years' effort had succeeded in increasing the economy of the steam engine, as shown by the performance of the best pumping engines, only to the extent of 20 to 25 per cent., and this through greatly increased steam pressure, compounding and presumably better boiler practice, was hardly calculated to lead one to expect anything very revolutionary in steam engine practice as exemplified at Chicago. It has been pointed out, time and again during the past twenty years, that nothing short of actual revolution could bring about more than a comparatively small advance in the economy with which steam was and is being used in the best examples of the steam engine. The possibilities of making a better machine of the steam engine, and gathering up saving in heat in small increments is all that has really been left for a good many years, if we consider the very best examples in the use of steam for doing mechanical work. But looked at in another way there has been and still is a great field for improvement; a field in which much progress has been made during the past twenty years, and in which there is still much room for progress. Not perhaps much ground that has not been worked in a way, but ground that can be better worked. What is referred to is the general application of that knowledge and skill in construction and operation that is evidenced in the results obtained in special and rare instances. That is to say the working along towards a universal performance of steam engines that shall approximate the best known performance instead of being several times inferior. If there was nothing startling in steam engineering seen at Chicago, nothing that indicated impending inversion, which must be admitted, it would be wrong to conclude that there was nothing there that stood for progress, progress on the only open line, that last referred to; wrong to conclude that the world is not getting wiser in matters pertaining to steam engine construction and operation, just as it is in most other things, not by stepping over mountains, but by the laborious process of going around them, or through them.

To note progress, comparison must be made, and it is rather convenient, as well as common in this country to refer mechanical progress to the Centennial Exhibition. The interval between the Centennial and the Columbian Expositions—nearly twenty years—seems long enough for the purpose of fair comparison. Generally speaking, the steam engine of 1893 will be found to be a better machine than that of 1876, made so by gradual advances, scarcely noticeable in some, and prominently so in other types.

It is a difficulty which every one has experienced, that of confining progress to time limits, exact, or even approximately so. Somebody is rather certain to show on some sort of authority or other—perhaps the very best—that you are badly out as to dates. What is believed by ordinary mortals to be new is very frequently shown by those

(*Continued on page* 9).

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Premiums on Naval Vessels.

The interesting statement comes from San Francisco that an error of 12 pounds has been proven to exist in the Navy department steam gauges used in testing the "Monterey" and the "Olympia," cruisers built by the Union Iron Works, of San Francisco, which works suffered pecuniarily on account of an apparent deficiency in the machinery of the first-named vessel, represented by 12 pounds boiler pressure. When just the same deficiency was shown in the second vessel suspicion was aroused, and the Mare Island Navy Yard gauges examined.

Of course there can be but one fair and honorable way of dealing with such a case, and that is to fully reimburse the Union Iron Works, even if a special law of Congress be required for the purpose; and in the meantime it would be very interesting to know just how the Government gauges came to be so much in error at a time when so much depended upon their being right.

It so happens that contemporarily with this discovery some little stir is being made about the matter of premiums paid by the Government to contractors for performances of vessels beyond contract requirements in respect either to horse-power or speed; it being charged that things are so arranged between the officers of the Navy and the contractors that large premiums can be readily earned.

There are, of course, a hundred ways in which engineers of the Navy department, so disposed, could arrange things so that certain favored contractors might know in advance that a large premium was to be earned on any given vessel, but we think if those who are charging such things against officers of the Navy were somewhat better acquainted with the methods of the department and with its personnel they would know that such a charge is about the last one likely to have any truth whatever in it.

The Use of the Indicator on the Locomotive.

A well and favorably known engineer, now dead, but at the time and for many years previous connected with locomotive building, expressed the opinion a few years since that the steam engine indicator had done nothing in the way of helping in the improvement of the locomotive engine. Without, now, questioning the absolute correctness of the statement at the time it was made, it will be readily admitted that even up to the present time the indicator has played very little part in locomotive engineering. There is reason why the indicator should have been of less practical utility in the instance of the locomotive than in that of almost any other type of steam engine. With the locomotive the chief consideration is the ability to get the heaviest train over the road on time, and this is, in the main, concluded by the possibility of the boiler in the way of furnishing steam. In changes that are made in the locomotive from time to time this limit of the boiler always stands as a reference; if there is freer steaming under given conditions the change is good, and *vice versa*. The coal burned has been, and in most instances still is, a matter of secondary and small consideration.

Then, again, special facilities for experimenting, always with the boiler as the chief point of reference, exist in the instance of the locomotive. There is the shop handy, and not much talk or any great amount of consideration if the experiment proves to be a failure. Experiment is, in part, what the shop is for.

Another thing that has prevented the general use of the indicator on the locomotive is that it is not so convenient to use it there as it is on other engines. It might be thought that this consideration would not have much weight, but there is no doubt it has been largely instrumental in preventing anything like its common employment.

As opposed to all this, in large manufacturing plants, there is usually an abundance of boiler power, or at least room for it, besides which the operation of the engine does not affect the steam making capacity of the plant in any way. There being no lack of boiler capacity the ability to keep steam is not in reference; at least it should not be, and generally is not. The coal pile is the objective point, and there is ample time to connect its rate of disappearance with different forms the diagram has been made to assume, the facilities for determining the exact coal consumption day by day, of course, making the comparison easy.

The matter of using the indicator regularly in the instance of the stationary engine is, as intimated, not only comparatively simple, but in large manufacturing plants it is expected that the engineer will make frequent use of it. So common has this become that no engineer can expect to be put in charge of a steam plant of much magnitude unless he is able to use the indicator understandingly. This for obvious reasons is not, nor can be, the case with locomotive engineers.

The ease with which the indicator can be used in the instance of stationary engines has led to a comprehensive study of engine performance in connection with the character of the diagram not only by engineers, but by builders of such engines. The engineer finds the cylinder of the new engine already tapped for the application of the indicator, and the builder encouraging its use; the latter has profited and proposes to profit by it. It is possible that builders of locomotive engines sometimes encourage the use of the indicator, but we never heard of an instance. They have never profited to any extent by its use, and do not see why they should. There has not been the same incentive to do so that there is in the instance of the builders of stationary engines who cannot meet the requirements by scheming for a little greater boiler capacity.

Quite recently, however, the use of the indicator has gained ground in railroad practice, and the use of compound locomotives is likely to help to bring it into more general use. There is a desire to get at the conditions existing inside the first and second cylinders, respectively, that will help if nothing else will. These conditions cannot be surmised so satisfactorily as with the simple engine, and curiosity, if nothing else, will prompt the use of the indicator for the purpose of determination.

Abuse of the A. S. M. E.

The Railway Review takes up the cry against the American Society of Mechanical Engineers, on account of its refusal to make tests of compound and simple locomotives, virtually charging that the society has acted in bad faith in the matter, because the society has failed to do as two of its members had thought it would do.

Because the society has simply adhered to its uniform practice in regard to such matters, by refusing to attempt to officially settle the relative efficiency of compound and simple locomotives, we are informed by *The Railway Review* that "Either the members are utterly ignorant of the subject with which they are dealing or are narrow-minded to a degree which is incomprehensible." We are further warned that "This action of American Society of Mechanical Engineers, together with its treatment of railroad subjects generally, will eventually lead to the railroad members dropping out or taking no active interest in the conduct of its affairs."

The absurdity of this has been shown in advance by our article printed week before last, and it is only necessary to ask our somewhat hysterical contemporary whether in its opinion the men specially interested in stationary engines are not also likely to drop out because the society has not attempted to decide the relative merits of simple and compound stationary engines; whether the boiler men will drop out because the society has not decided whether shell or water tube boilers are best; whether the machine tool men will drop out because the society has not attempted to decide whether milling machines or planers are most economical for producing plane surfaces on iron?

The more our railroad contemporaries attempt to show up the shortcomings of the A. S. M. E. in this matter, the more apparent it becomes that the society has made a wise decision in declining to attempt to settle a matter which can, after all, be settled only by the roads themselves, assisted by such data and information as may be made available by the recorded experience of others as presented before the various societies and there discussed.

Literary Notes.

CONTINUOUS-CURRENT DYNAMOS AND MOTORS, Their Theory, Design and Testing. With Sections on Indicator Diagrams, Properties of Saturated Steam, Belting Calculations, etc. An Elementary Treatise for Students. By Frank P. Cox, B. S.

This work gives the theory and design of continuous current dynamos and motors as understood and practiced in the designing room, and the methods described are those of the factory testing room. The descriptions of different machines and systems are excluded, but we know of no work in which the general principles of current-induction, theory and design of dynamos are stated and demonstrated in a clearer manner. The work is intended for students, but the practical side of the various questions treated, which has never been lost sight of, makes the book extremely valuable to the practical man and designer also.

The first four chapters consist of a brief review of the electrical units and the general principles of the machines, and may be considered as an introduction to the subsequent portions; the higher branches of mathematics are avoided, as elsewhere a knowledge only of algebra and the elements of geometry is assumed. Chapter V. is on calculations pertaining to magnetic circuit; Chapter VI. treats on the theory of windings, losses, etc., and Chapter VII. of the special points to be observed in motor designing. In Chapters VIII., IX. and X., the application to the design of armatures, field magnets and motors of the principles developed in the preceding chapters is explained by reference to numerical problems selected so as to cover as broad a field as possible, and show in what manner to make the various compromises always necessary in practical designing. In Chapters XI. and XII. the methods of testing a completed machine and the effect of various changes in design and operation are discussed and illustrated by numerous curves.

As the subject of steam engine is closely connected to the testing and operation of dynamos and motors, the last two chapters are devoted to indicator diagrams and steam power calculations.

The four appendices are on tests of irons, ampere turn-tables, determination of sizes of wire for armatures and field coils, and on the calculation of belting.

The book is published by The W. I. Johnston Company, Ltd., 41 Park Row, New York. Price, $2.00.

QUESTIONS AND ANSWERS.

Questions of general interest relating to subjects discussed in our columns will receive attention in this department. The writer's name and address should always accompany the question. Neither correct initials nor location will be published when there is a request to that effect. If questions are enclosed with a business communication, they should be written on a separate sheet.

(27) A. S., New York, writes: Kindly advise me through your columns if you know of a liquid which will remove oil and grease from brass, and which is not so inflammable as benzine? *A.*—Use a solution of concentrated lye.

(28) H. N. S., Newton, Mass., writes: In one of your issues you state in answer to a question that an engine with a cylinder 1¼ inches diameter and 2 inches stroke will require a fly-wheel whose rim weighs 20 pounds. Is this not a mistake? If so, please give me the correct weight of rim of

fly-wheel for the above engine. *A.*—We believe the weight of the rim as given by us is correct for close regulation and good running; if these are considered to be of secondary importance, a lighter fly-wheel will answer the purpose.

(29) H. N. L., Marion, O., writes: Please inform me where I can obtain a receipt for browning and bluing steel and iron. *A.*—For the chemical process, see "Metal-coloring and Bronzing," by A. H. Hiorns, published by Macmillan & Co., New York. A blue color on iron and steel can also be obtained by heating them. For this process, see our issue of October 2, 1890.

(30) A. G. Z., ——, asks: Please inform me whether or not there is a machine made to make set screws faster than they can be made on a turret lathe with hollow mills? *A.*—No machine that we know of will make them faster, but they may be made at lower cost on automatic screw machines. 2. Is there a hollow spindle lathe built with a compound rest? *A.*—Yes. A great many tool builders build such lathes.

(31) T F., Cleveland, O., writes: Please inform me in regard to the following: When a piece of steel is hardened and polished, and the temper drawn to a straw color, or any other color, and then is allowed to cool off, and then again drawn to the color it was at first, what effect has this on the steel; will the steel be softened, if so please explain? *A.*—There are tool makers and steel workers who claim that drawing the temper a second time will change the first temper and tend to soften the tool. There are others who do not believe this.

(32) J. D. F., Montreal, Canada, asks: Have you the newest and best formula for brown cold lacquer for salmon canner's use, instantaneous drier, bright and enamel like, to stand reducing with 250 per cent. of benzine when cold without precipitation? *A.*—We have not such a formula. 2. Is phosphor bronze a good conductor of electricity? Is it as good as copper? *A.*—Both are good conductors, comparatively, copper is the better conductor of the two. 3. Do acids give resistance, or do they act as a conductor, I refer to sulphuric and nitric acids? *A.*—These acids are good conductors among fluids, but all conductors offer resistances.

(33) X. Y., New York, writes: Kindly inform me the best metal to use for an eccentric, as described below, in order to prevent it from heating. I have tried cast-iron with plenty of oil and grease, but it would heat. Throw of eccentric, ½ inch; inside diameter of strap, 4 inches, and width of same, 2 inches. The strap is central on a 4¾ inch bearing, and the eccentric is fastened on shaft by two set-screws. The shaft runs at 300 revolutions per minute, and the power necessary to run the machine is about 4 horse-power. *A.*—We do not know of a better metal for the purpose than good close-grained cast-iron. The cause of the heating is evidently due to an excessive pressure per square inch of projected area of the eccentric. To avoid heating, the width of the eccentric will have to be much increased, and probably an increase of the diameter will also be necessary, but the latter should be kept as small as possible, so as to keep a low velocity at the circumference.

(34) E. S. Z., Dayton, O., writes: Please give me the dimensions of a 2½ horse power steam engine? *A.*—Cylinder, 3½ inches diameter, 4 inches stroke; this engine running at the rate of 400 revolutions per minute, and with 40 pounds mean effective steam pressure will develop the desired horse-power. 2. Please give me a receipt for silvering pewter without the use of a battery? *A.*—Cut into small pieces a twenty-five cent piece, and put it into an earthen vessel, with ½ ounce of nitric acid. Put the vessel into warm water, uncovered, until it dissolves. Add ½ gill of water and 1 teaspoonful of fine salt, and let it settle. Drain off and repeat, adding water to the sediments until the acid taste is all out of the water. Add finally about 1 pint of water to the sediment, and 4 scruples cyanide of potassium. Put in the solution a piece of zinc about 2 inches long, 1 inch wide, and ½ inch in thickness. After cleaning, immerse the article to be plated in the solution about half a minute, letting it rest on the zinc. Wipe off with dry cloth, and repeat once. Polish with buckskin. The thickness of plate can be increased by repeating. We cannot answer your third question; the letter was written in pencil, and the main part of the question obliterated.

(35) S. T. W., Baltimore, Md., writes: Please give me a recipe for a cement that can be cast to shape in a metal mold, and will be fairly smooth when hardened, also hard enough not to be cut by a knife. The articles which are to be made will not weigh more than an ounce? *A.*—We do not know of a cement that will suit your purpose. We have seen excellent work made with India rubber, the articles being very light, hard and smooth; how to manipulate the India rubber, and how to cast it in metal molds has been thoroughly explained by J. T. Usher in a series of articles commencing in our issue of October 15, 1891. The process, in skillful and experienced hands, is not at all an expensive one. 2. In the gas engine the gases are ignited, causing an explosion and consequent pressure, which drives the piston; on the return stroke the burnt gases are expelled. Now if it were possible to block the wheels so as to hold the piston at any point on the power stroke, then introduce the gas and air in proper quantities, ignite and explode the gas, how long would the resultant pressure remain in the cylinder? In other words, is it a sudden expansion that must be used at once, or is it a pressure created by the liberation of so many heat units? *A.*—By exploding the gas a pressure is produced, and this pressure will not be changed so long as the temperature and volume remain unchanged. 3. What is about the average or estimated number of steam engines built in the United States in a year? *A.*—We do not know.

(36) T. A., Galt, Canada, writes: I am a machinist, and would like to become a marine engineer. What course will I have to pursue, how long will I have to work in a marine shop, and what books should I study? *A.*—According to the rules of the Board of Supervising Inspectors of Steam Vessels in the United States, you must have served at least three years in the engineers' department of a steam vessel, or as a regular machinist in a machine shop before you can obtain a license. The course of study to pursue in your leisure hours is indicated in our issue of February 19, 1891, in an article on "What to Study and How to Study," in which the books required are also mentioned. For your purpose it will be best to read occasionally some of the books treating on steam engines and boilers mentioned in the same article, while you are progressing in your elementary studies. This course of study may seem to be a very laborious one, but the complicated machinery put in recent vessels increases the responsibility of engineers, and to fill these positions in first class ocean steamers requires men of a good sound education. If you faithfully follow the course indicated, we believe you will have no occasion to regret it, particularly after you have gained the desired ends. 2. Where can I get a list of the questions asked at the examination? *A.*—There is no such list; the questions will be such as to test your fitness for the position. 3. Are there any marine shops in Ontario? *A.*—Yes. 4. What wages do marine engineers generally get? *A.*—That depends on the company who engages your services, and the grade of your license. The wages vary from $60 to more than double that per month.

(37) Y. K. W., Erie, Pa., writes: Kindly give a solution of the following problem; do not use algebraic forms. The observed performance of a boiler was: Water evaporated per hour, 6 8 pounds; coal consumed, 1 pound per hour; steam pressure by gauge, 68 pounds; temperature of feed water, 176 degrees Fahr. What is the equivalent evaporation from and at 212 degrees? *A.*—For computations of this kind the absolute steam pressure must be taken, which is equal to $68 + 14\ 7 = 82.7$ pounds; for convenience in referring to tables of the properties of saturated steam, say 83 pounds. One pound of steam at 83 pounds absolute pressure contains 1,209.8 units of heat; the temperature of the feed water is 176 degrees; hence $1,209.8 - 176 = 1,033.8$ units of heat required to raise each pound of steam to the given pressure, but 6.8 pounds of water have been evaporated by 1 pound of coal; hence the total number of heat units given out by 1 pound of coal will be $1,033.8 \times 6.8 = 7,029\ 84$. To evaporate 1 pound of water at and from 212 degrees requires 965.7 units of heat; hence dividing the units of heat given out by 1 pound of coal, as found above, by 965.7, we have $\frac{7,029\ 84}{965\ 7} = 7.27$ pounds of water evaporated from and at 212 degrees. Subtracting the temperature of the feed water from the units of heat in a pound of steam, as we have done, is not strictly correct, because as the temperature of the water is increased above 176 degrees, the addition of a heat unit will raise its temperature slightly less than one degree, but the decrease is so slight that it need not be considered. For all ordinary purposes we may calculate that if we add one heat unit to a pound of water below 212 degrees it will increase its temperature one degree.

(38) R. E. H., Fort Wayne, Ind., writes: Please let me know if a person must have a good knowledge of arithmetic to learn algebra, geometry and trigonometry; and if so, can a person obtain a good knowledge of arithmetic without a teacher by studying books used in the public schools? *A.*—You can obtain this knowledge yourself without a teacher, but be sure to commence with the elementary works. Arithmetic is the most elementary branch of mathematics, and therefore it should be studied first, or at least a part of it, before the other studies are taken up. It is not necessary to have an extensive knowledge of arithmetic to learn geometry; in fact, our advice is to take up these two studies conjointly, as the knowledge of one will help to obtain a more thorough knowledge of the other. With perseverance you should be able to master these studies without a teacher; of course, with the assistance of one your progress will be more rapid. A knowledge of arithmetic is necessary for the study of algebra, and a knowledge of geometry will greatly aid you in your progress; trigonometry may be taken up last. 2. Can you tell me if there are any books better than elementary algebra, elements of geometry and trigonometry, by C. Davies? I never had much schooling, but have served as a machinist, and desire to become one of the best. I cannot afford to go to night school. *A.*—We believe that C. Davies' works are as good as any books treating on the same subjects. In studying these works do not pass over the beginning of each study hastily, but be sure that each step is thoroughly understood before you advance to the next one, so as to lay a solid foundation for the more difficult problems. Your desire is very commendable, and with a corresponding amount of perseverance you will surely succeed.

(39) R. L., Auburn, N. Y., writes: In reading works and articles on the steam engine I frequently find a statement to the effect that it is not economical to expand steam below the pressure that will overcome the friction of the engine; also the loss that comes from making a pump of the engine. I do not understand this. Can you explain? *A.*—Such statements standing by themselves are misleading and, if true—particularly the first one—are so by accident only. It would be bad practice, generally, to design a non-condensing engine, which, we understand, you refer to, so that steam would, with the regular load, be expanded lower than about five pounds above atmosphere. But this is something, so far as the economical use of steam is concerned, with which the friction of the engine has nothing to do. It might quite as well be said that expansion should not be lower than the pressure required to drive the "big planer," or something of the sort. But it is one thing to design an engine for a definite load, and another thing to operate it under existing conditions as to load, steam pressure available, speed, etc. Suppose it took 20 pounds pressure to overcome the friction of the engine. It would not be good steam economy to stop expansion at 20 pounds above atmosphere, which you would do if you took the first statement literally. The conditions in operating a steam engine are frequently such that it is economical to carry expansion to, or even below, the atmosphere. When expansion in a non condensing engine is below the atmosphere it is likened by some to a pump, we suppose, because when the exhaust valve is opened the flow will, at first, be into instead of out of the cylinder. If this in-flow was of air of ordinary temperature it would tend to cool the cylinder. But the inflow is generally through a pipe of considerable length the contents of which are nearly as warm as—perhaps warmer than—the contents of the cylinder, so that under conditions ordinarily obtaining no particular harm results.

(40) H. P. P., New Orleans, La., asks: Is there a way for determining the mean effective pressure from a steam engine indicator card by finding the area of the card, and from this the required pressure? If there is, please give an explanation of the method? *A.*—The most accurate and expeditious way to measure the mean effective pressure represented by the diagram is by means of the planimeter or averaging instruments; but as such an instrument is not always at hand it may by careful working be very accurately done by dividing the diagram into a number of equal parts, perpendicular to the atmospheric line, say 10, measuring the height of each division, adding these measurements together, and dividing the sum by the number of divisions. The only reason for making the number of divisions 10 is for convenience; some prefer to make the number 20, as tending to greater accuracy. The height of each division can be measured by the scale of pounds, the measurements added together and divided by 10, the result appearing in pounds; or the measurements can be made by a scale of inches, the sum multiplied by the scale of the spring, and divided by 10, giving the same result as before. As tending to greater accuracy, however, it is advisable to make the measurements continuous. For this purpose a strip of paper is used, which is carried from one division to another, the measure of each being pricked or marked beyond the preceding one, so that the distance from the end of the strip to the last mark will represent the sum of the 10 measurements. You will find this subject thoroughly discussed in "Indicator Practice and Steam Engine Economy," by F. F. Hemenway. By using a planimeter the area of the card is obtained. To compute the mean effective pressure from this area, proceed as follows: Divide the area in square inches of the card by its length in inches; the quotient will be the mean or average height of the card; multiply this by the scale of the indicator; the result will be the mean effective pressure. If, for instance, the area is 2 48 square inches, the length of card, measured parallel to the atmospheric line, 4 inches, and the scale of the indicator equal to 40, we then have:

$$\frac{2\ 48 \times 40}{4} = 24.8 \text{ pounds}$$

for the mean effective pressure.

BUSINESS SPECIALS

Transient Advertisements 50 cents a line for each insertion under this head. About seven words make a line. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue.

Grant's Gears, Lex'n, Mass., & Phila., Pa. See p. 12.

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"Indicator Practice and Steam Engine Economy." By F. F. Hemenway. Contains plain directions for using the indicator and making all required calculations from the diagram, also the principles of economy in operating steam engines and current practice in testing engines and boilers. Price, $2 postpaid. Published by John Wiley & Sons, 53 East Tenth Street, New York.

Monthly Meeting of Mechanical Engineers.

(*Continued from page 7*)

who have the faculty of upsetting things, and who take delight in doing so, to be more than old in the way of invention. But on the other hand, invention is not necessarily progress, and the putting of invention to practical use is progress. Dates must be referred to in an indefinite manner, sometimes, and usually with the proviso that an exception or two—more or less—does not disprove a general rule.

In the matter of compounding, compared with the Centennial, there was evidence of notable progress at Chicago. At the first named exhibition there were no compound engines; at the last named, compound engines—two cylinder, triple and quadruple expansion—were the rule. Compounding is old, but at the date of the Centennial was not in repute for the more ordinary purposes for which steam engines are employed. For such engines, at least, the economy of compounding was boldly disputed by some engineers, and more than questioned by others. Little doubt as to its superior economy exists to day. Scarcely more than ten years ago it was very easy to start a discussion between engineers as to the relative merits of simple and compound engines, as regards the economical use of steam. It is scarcely possible to do so now. That this is so is due to a better knowledge of the whole

matter. The exhibits at Chicago showed, it seems to me, two things in relation to compounding, one of which was that progress has been made, and another that there is still room left for progress. There were some very fine examples, and some in which the effort to engraft the second cylinder upon the first was hardly felicitous. As one well-known engineer put it, the cylinders were not always neighbors, which may have covered other considerations than that of distance. But some undesirableness must be expected of anything in the transition state. A move in the right general direction, if not in the most direct line, represents progress compared with standing still.

Comparison between the two largest engines—the Corliss at the Centennial and the Allis at Chicago—is unsatisfactory because of the difference in principle and in constructive detail. One was a vertical and the other a horizontal, one simple, the other compound. Considered architecturally, to misuse a term for the sake of convenience, I should think there was nothing at Chicago that could compare very favorably with the Corliss at the Centennial. Probably in the best interest of progress there ought not to have been. In war, there is perhaps nothing that will compare with the altogether useless charge of the Light Brigade. The Allis engine was of greater capacity, and, aside from this, it would, beyond doubt, furnish a horse-power for less expenditure of coal, and the chief end of a steam engine is to furnish, all things considered, horse-power for little money. Both these engines were Corliss engines as the term is employed at the present day, and the Centennial engine was certainly not behind in its mechanical performance. Nothing could behave more admirably as a machine.

The most noticeable point of difference in the valve mechanism of these engines was the employment of a supplementary eccentric in the Allis engine for controlling the point of cut-off. By the operation of this, the unlatching could occur at any point up to practically full-stroke. Objection, not very weighty, perhaps, but having some force, has frequently been made to the ordinary Corliss gear on simple engines because the steam valves must be tripped, if at all, somewhat before the half-stroke of the piston. This objection, for obvious reasons, would have greater force in the instance of multi-cylinder compound engines. This second eccentric, as used, appears to be a desirable improvement. It is only proper, however, to say that the end aimed at by the use of this eccentric has for some time—and notably in England—been at least partially accomplished by the use of two eccentrics, one for the steam and one for the exhaust valves. By this means it is possible to extend the point of unlatching until, practically, half-stroke, and this will prolong the expansion until about three-quarter stroke, the piston at half-stroke being at its fastest travel; this—three-quarter stroke—is perhaps late enough for cut off in any engine used for ordinary purposes.

The time required for valve closure after unlatching in the Corliss type of engine was very well shown by an experiment made several years ago by some of the bright young students of Massachusetts Institute of Technology. This experiment was made with an 8″x24″ Harris-Corliss engine, by blocking the governor and loading the engine by means of a brake, then while the engine was running gradually, though comparatively quickly, releasing the brake friction, the pencil of the indicator being all the time in contact with the paper on the drum. By this means a series of diagrams were taken on a single card, the point of unlatching of the valve being, as explained, constant, while the speed of the engine increased as the load was decreased. The point of valve closure, as shown by these diagrams, was all the way from before half-stroke up to later than nine-tenths stroke, the speed of the engine at the conclusion of the experiment being estimated at over 150 revolutions.

It may be mentioned that gain in power, as shown by these diagrams, by prolonging expansion beyond three-quarter stroke, was trifling, the increased forward pressure on the piston being nearly neutralized by an increase in the back pressure, although the steam line showed but little drop in pressure.

It seems probable that there is some gain—and it is so stated by those familiar with the subject—in the use of separate eccentrics for steam and exhaust valves through the possibility of a more advantageous arrangement of the exhaust valves and their operating mechanism, as the steam valves are not influenced by the change made in this respect. The use of separate eccentrics for steam and exhaust valves as referred to was not, so far as I know, in evidence at Chicago, nor do I know when they were first employed. I am assuming that their use does not antedate the Centennial, in which I may be in error. They were, I am informed, so used by the E. P. Allis Co. as early as 1886, but are not recommended by them except in the instance of the low-pressure cylinder of triple-expansion engines when it is desirable to carry expansion beyond half-stroke, and sometimes in the instance of two-cylinder compounds for the same reason. The chief reason why the two eccentrics are advised against by this company is, I believe, the fact that the engine does not handle so conveniently when they are employed. I also believe, though I am not quite certain, that the Atlas Works, of Indianapolis, used two eccentrics, something in the way indicated, at an earlier date than that mentioned.

Of the engines possessing to an extent greater or less some of the features of the Corliss, and designed to avoid what are claimed to be undesirable characteristics of this engine, not much can be said; the value of new arrangements of details should not be judged hastily, but time should be given in which to demonstrate their utility, or the contrary. Progress sometimes consists in going backward, which may or may not yet be illustrated in the instance of some of these engines at Chicago. There has, broadly speaking, been but little improvement in Corliss engines since the Centennial, and for some time previous to that. Some little modification of details has been made, undoubtedly in some instances of value, and a large amount of good material and workmanship, and a world of ingenuity have been wasted.

One engine, the Bates-Corliss, was provided with a very neatly worked-out scheme for doing away with unlatching, at the same time preserving its equivalent. If unlatching is very objectionable, which I do not believe, this provides a way around it. As perhaps all of you know, there is in this plan a sort of doubling up, or back, in the steam valve connection which is provided for by the operation of the governor; a sort of collapsing that may be likened to a toggle joint under pressure, forced beyond the center line and free to move further.

This detail I suppose to be new, and it is, perhaps, yet to be demonstrated that something more objectionable than the unlatching of the Corliss motion is not developed by use. It appeared to work in every way satisfactorily.

High-speed engineering cannot be said to have come into existence since the Centennial, but its growth has been mainly since that date. Previous to that the Buckeye Engine Company had built some quick-running engines for saw-mill work, I believe, and Mr. Charles T. Porter had built a few high-speed engines, and was engaged in missionary work, which he continued, and which has left his mark, if not as plainly written on rapid-revolution engines as that of Corliss on those of slow revolution, quite as effectively, perhaps, so far as results go. It is not necessary to mention the influence of the correct workmanship introduced by Mr. Porter, workmanship that made high speed practicable. All know of it, and thousands have profited by the example. In addition Mr. Porter originated a form of bed that has demonstrated a good many times that it is easier to modify and change something than it is to improve it. The outcome of his work—his example—was in indirect evidence at Chicago in the numerous examples of fine high-speed engines exhibited. Nothing like this exhibit would have been possible fifteen years ago. This is particularly true of single-valve automatic high-speed engines with shaft governors, which have almost worked a revolution in some branches of steam engine construction since the Centennial. There were, I believe, but two examples of stationary engines with shaft governors at the Centennial, the Buckeye and the small high-speed Straight Line by Professor Sweet. The latter has been so modified since then as hardly to be called the same engine. To these may be added the portable engine by Hoadley, making in all three engines with shaft governors. The portable engine named is not now built that I am aware of. These engines are referred to as showing the wonderful growth of this type of engine—those with shaft governors—as shown by contrast with the exhibits at Chicago.

The discussion as to the relative merits of high and low-speed engines has been warm in previous years, the outcome of which is a pretty thoroughly settled conviction that each is best in its field, although the boundary lines are not very clearly defined. The high speed engine has come to stay because it fills the proverbial "long-felt want," and the low-speed stays because its retirement would leave a void.

Along with the requirement for better construction brought with the high speed engine was that of improved methods of distributing oil. Getting a little oil, once in a while, where it would do some good, would not do, as the revolutions and reciprocations got way along up into the hundreds; getting the right quantity—or at least enough—at the right time, where it would do the most good, was demanded, and hence the ingenious arrangements to that end shown in connection with the engine exhibits at Chicago—all of modern growth.

Something the same may be said of balancing. Correct practice in this respect was an essential of high speed, and a great deal of attention has been given to it and a good deal learned about it during the past ten or fifteen years. With the many examples of fine balancing shown at Chicago, it would be unfair to make special mention were it not for one instance of an engine—the "Ide," I believe—which may be taken as an example of other practice; this engine was shown running very quietly, mounted on small wooden blocks—stilts.

Great advances have also been made in controlling the speed of high-speed engines. So perfect is the best practice in this respect that almost any degree of refinement will be guaranteed. Progress in high speed engineering was exemplified at Chicago, in part, by greatly improved design and workmanship, better means of lubrication, better balancing and better control of speed.

The display of steam engines other than those made in the United States was so limited as to give but little idea of recent European progress or practice; although we may in a general way be informed as to this, it would have been very satisfactory to have seen it better illustrated by exhibits.

The Willans engine was an interesting example of comparatively recent date. Its special novelty is in its central valve for steam distribution, and the means for cushioning independently of the steam distribution in the cylinders. The central valve arrangement affords excellent means of getting rid of water in the cylinders, and the cushioning by means of the direct air cylinder results in smooth running without any effort at steam distribution to that end; something that I should think very likely to receive more attention in the future. This engine has what are usually believed to be the disadvantages of rather unusually short stroke, is single-acting and has a throttling governor, and yet it is credited with remarkable economic performance. As to its performance under test, it may be remarked that with a properly adjusted load and constant steam pressure the objections to a throttling governor disappear. This engine is, I believe, used largely in England for electric lighting, the installation very commonly being such that of several engines only as many need be kept in operation as will be what is considered properly loaded, the governing being done by a single engine. I am informed that they are manufactured strictly interchangeable in every detail; something that, so far as I know, cannot be said of any other engine. This does not necessarily make the engine better, but it must cheapen the cost of production.

There was nothing, I should think, especially noticeable in the vertical German engine, except evidence of good design and workmanship. The use of the Rider cut-off valve never found especial favor in this country, which is not, however, said as in any way against it. Balancing the weight of the valves and connections by means of steam cylinders over them is not very new, at least; connecting the top of the balancing cylinders with, in the instance of the intermediate cylinder, the low-pressure steam chest, and in the instance of the low-pressure cylinder, the condenser, while steam underneath the balancing pistons is taken from the respective steam chests, may or may not be novel.

The German portable and semi-portable engines were examples of elaborate construction beyond what we see in this country, but further than this, and the evidence of good general design, presented no very novel features.

The French engine, by Schneider & Co., was mainly interesting as showing conclusive evidence of progress in the molder's art as applied to the making of castings for steam engines.

An evidence of the coming use of air cushioning was shown in the large Westinghouse engines by an air cylinder attachment to the high-pressure valve, which it would seem must assist the governor very materially.

The most interesting example of progress in steam turbines appears to have been shown by the De Laval machine, in which a speed of as high as 30,000 revolutions is attained, the benefits of expansion being obtained by the use of a tapered nozzle, the smallest diameter being at the inlet. The commercial value of this machine may be doubted, but it is certainly, in its operation, a wonderful little engine.

In direct-acting pumping engines, notable progress since the Centennial was shown by the Worthington high-duty engine, with which you are all familiar. In direct-acting pumps of smaller size, a good many have come into existence since that time, and as in steam engines, compounding is fast gaining ground.

Another noticeable feature is the growing popularity of independent condensing apparatus. Such apparatus has been in limited use for a long time, but it has been brought to its present state of perfection since the Centennial. Very fine adaptations were shown at Chicago, not less noticeable for their creditable operation than for compactness of arrangement and good general design.

A great impulse was undoubtedly given to this branch of steam engineering by the advent of high speed, and recent progress, as illustrated at Chicago, has been very decided.

An unfortunate feature of the engine exhibit was the numerous breakdowns and failures of some of the engines which were apparently in the experimental stage, something that was not to be expected at an exhibition of the character of this. It would seem to be a poor place to try experiments. Some failure is to be expected in the instance of a new departure in construction, and it is generally the case that some of the details must be changed or modified. But visitors generally conclude that this has already been attended to, as it ought to be, before public exhibition, and their criticism is, and justly, of what is and not of what might have been.

PROF. JAMES E. DENTON—When a subject has been discussed as thoroughly as brother Hemenway has discussed this subject, it is hard to find anything further to say about it. I thought of one little principle which was shown at Chicago that I did not hear him mention; that was a vertical engine built by the Allises, in which the steam was handled as the charge of air and gas is in a gas engine; that is, the governor, when the engine was above speed, kept the valve entirely shut, and when the engine was below speed, it opened the valve at a fixed cut-off. The idea was to avoid a short cut-off at light loads, and thereby reduce the cylinder condensation. It was a great disappointment to the committee on engines that some tests could not be made of that engine to determine whether there was anything of value there, because we all know that the entire improvement represented by compound as compared with simple engines is the mere reduction of cylinder condensation for a given ratio of expansion. What compounding or multiple expansion has done is of course simply to keep the per cent. of water unaccounted for by the indicator constant as the ratio of expansion has changed from 4 or 5 to 25, and that engine of the Allises, aiming at the reduction of cylinder condensation in that peculiar way, it would have been very interesting to have had a chance to try it. Of course the quadruple expansion engine at Chicago only has a chance to save over the triple expansion engine of Frazer and Chalmers, which was alongside of it, by reducing the cylinder condensation, and there is no doubt, I think, that the quadruple expansion, reducing the range of temperature in the first cylinder, would give us less cylinder condensation, and that there would be some gain. But there is the question as to the extra cost of that fourth cylinder, in its interest, and in charges for repairs, overweighing the gain in coal, and the probability is that the difference is so very close that it was a fair expectation for the triple expansion people to believe that they could have nearly equaled the quadruple expansion economy. As I suppose most of you know, tests were not made at Chicago. The hurry and rush there, and the lack of funds prevented any test being made, and that opportunity, which was a rare one, to try the quadruple principle against the triple principle, was lost. There would have been a great difficulty in getting a load.

Speaking about the gain in economy due to the reduction of range of temperature, the Willans engine stands forth to-day as having accomplished the most wonderful results; and if they can realize in every-day practice what they have recently put forth as their economy, with condensers, the practice of using a large Corliss plant to drive dynamos is going to give way, I think, to such engines as that. I do not know how many of you have seen the recent tests on that engine. With 400 revolutions a minute, with 170 pounds of steam and with only 13 expansions, the Willans engine claims 12¾ pounds of water, and that is as low as we can rely upon a Corliss triple expansion engine giving us, as yet. The only case that is on record improving upon that is, of course, the Milwaukee pumping engine. But the Willans engine also offers the simplicity of a throttling governor and challenges the world to show that the automatic cut-off will ever save anything of any account. As Mr. Hemenway has well said, when the range of expansion is the same for two engines, one with automatic cut-off and one with a throttling governor, the loss by using the throttling governor to regulate the speed is probably too small to find, except with the very finest tests.

A little matter of interest on that point is that Mr. Charles T. Porter, who has been referred to, very justly, as one of the pioneers, is now devoting his energies and has thrown his soul very intensely into the idea of regulating engines by a throttling governor and running the valve with a cam. He old me before I went to Chicago that I would not see anything there that was going o compare, as an improvement in steam engines, with the results obtained from his cam, and certainly he has got a very beautiful thing. If that cam does away with the noisy and irregular action of cams, he believes now that the automatic cut-off must give way again to the throttling governor.

One point I would like to gain information upon, and that is in reference to the cushioning. We know that when Mr. Porter first started to build high-speed engines—his first exhibit was at the Paris Exposition—he built an engine running 200 revolutions a minute, and it ran so smoothly that it astonished the world, and about that time he became a great exponent of the principle of absorbing the pressure of the crank-pin by the reciprocating parts—the weight of the reciprocating parts. He came to this country, you know, and built the engines in a general way on a large scale, and built them with all the accuracy of workmanship that could be brought to bear on an engine, and he did not use any cushioning—he did not use hardly any cushioning. The engine at Paris had not used any cushioning, and yet after the engines had been tried a little while they began to thump tremendously, and the Southwark Foundry had to deliberately go throughout the country and put a good deal of compression in all the engines they had put out to stop the noise, and yet Mr. Porter has said in recent times that the compression had nothing to do with the noiseless running of the engine. The locomotive has long been before us as a practically noiseless high-speed engine. It uses a great deal of compression, and as it crosses the center its force upon the crank-pin is practically zero. So was Mr. Porter's Paris engine, because he made the weight of the reciprocating parts such as to entirely absorb all the steam pressure, and that is about the situation of the locomotive. An English writer, whose name I cannot recall at the moment, reviewing the Paris engine said that the principal of acceleration had nothing whatever to do with the smoothness of the running, but it was the workmanship. It was certainly the fact that there was no pressure on the crank-pin in crossing the center, and that is the case with locomotives. To day all our high-speed engines for electric lighting use cushioning, but it was because they had to with the single valve. So that we cannot prove from them that the cushion is necessary for noiseless running.

The point has been referred to by Mr. Hemenway that there was not much progress shown by the exhibits. I think he handled that very nicely, because while there was nothing radically new in the exhibits at Chicago there was something which was of a great deal more value, and that was the development and perfection of details. We all know how far it is from the germ of an idea to the reliable use of that idea, and the exhibits at Chicago certainly showed that there had been a general adoption of workmanship, design and care in details that made engines more reliable, entitled them to confidence as trustworthy machines. That is all there is in the Corliss engine to-day. (Here the hammer fell.)

MR. ROCKWOOD—In making my rounds amongst the engines at the Fair I think the most astonishing thing that I saw there was the air pump of the Schichau triple expansion engine. Those who have not undertaken to design air pumps do not know what they will have on their hands when they do get that duty. The difficulty of making an air pump to run at a speed of 225 turns a minute, connected to an engine and running perfectly noiselessly as that one did, is, I confess, beyond me, and I have not seen any air pump in this country that could do it. I have seen a good many air pumps that thump and shout and rumble and wear out their valves and give the engineer trouble and annoyance and take up valuable time, and finally, perhaps, in many cases, decide the engineer in charge to change over to some other kind of condenser, perhaps independent. But no one who saw that air pump run would want anything else to get rid of his water of condensation. I asked the German engineer how he did it and he drew out something perfectly familiar, but I was just as much in the dark as before.

I do not propose to again state before the society on my own authority the advantages that certainly, in my opinion, lie with the 2-cylinder compound designed on the triple expansion engine theory, without its intermediate cylinder. But I think that the results obtained from such compound engines are sufficiently remarkable to be noticed. Prof. George I. Alden, recently one of the vice presidents of the society, made a test of a compound engine of that style, the very one, in fact, which I had previously tested and reported to the society in connection with Prof. Thurston's paper on the Milwaukee engine. Prof. Alden has made a test of this engine with his corps of instructors and his results in steam consumption were 12.9 pounds per horse-power per hour. He had a very accurate way of finding out the amount of moisture in the steam independent of the calorimeter, so that that may be taken as water consumed by the engine. There was no moisture, because the boilers superheated the steam, and the pipe was not long enough, together with the separator, to make moisture.

If we ask engineers what they think can be obtained from Corliss compound engines having, say, a cylinder ratio of 1 to 4, I think we shall hear that these engines will give all the way from 14 pounds in extremely good cases to 18 pounds. I remember Prof. Carpenter made a test of an engine at Utica which took 16.4 pounds. That was a new Corliss compound engine and it was tested with great care by Sibley College; and this engine, giving 12.9 pounds of steam, by the test of Prof. Alden, seems to me to afford quite a contrast.

MR. KENT—I would like to ask Mr. Rockwood if the engine was running under a very full load when the air pump was so noiseless, and if not, if he knows whether the air pump would be noiseless under full load.

MR. ROCKWOOD—I do not know to the contrary. I saw two big engines running and a little engine. When I saw it, it operated with such sweetness that I was amazed.

MR. BAKER—It may be remembered that the Lake Erie engine, at Chicago, carried for a large part of the time the entire load of the railway, and we are indebted to the electrical part of the engineering profession for the development of that type of engine and its coming into very extensive use. It is not, so far as I know, any attempt to gain anything in steam economy that has brought it into use, but it has been the need of getting the greatest power in the least space. It may be of some interest to the members to know the latest development of that type of engine which I may say has never been published in any technical journal. I refer to an engine which generates 100 [?] horse power for every square foot of floor space occupied—a 2,500 horse-power quadruple expansion, 2-crank engine, with the high-pressure and first intermediate working on one crank and the second intermediate and low-pressure on the other crank. It has an 800 kilowatt generator mounted on each end. That is built by the Dixon Manufacturing Company for the ——— street station of the New York Edison Electric Company. That is about the limit of what has been reached, so far as I know, in that type of engine. It is a very interesting departure, this putting engines up on end in that way instead of spreading them out over the floor as we have been accustomed to do. The governor regulates the cut-off on all the cylinders simultaneously, which should give a very close regulation, and there are piston valves on all the cylinders, which probably will not help steam economy, although they think it will save some trouble. In an electric light station, what is wanted is an engine that will be reliable, above everything else.

MR. ROCKWOOD—Speaking of piston valves, that was another remarkable thing at the World's Fair. A friend of mine invited me to inspect the Ide engine piston valve. It was connected to its rod through the medium of a ball joint. The engine was running. It was under steam pressure. He suggested that I take hold of this ball joint and turn the valve around while it was running. I did not think I could do it, but I did it with two fingers. In fact there was no resistance beyond what you would expect if there was no steam pressure and no friction. Mr. Barrus had steam on it and the heads off the ends and no steam issued around the valves. I think that is a remarkable thing about piston valves. Piston valves have a bad name for leaking, and these valves did not leak. If this designer can make piston valves that do not leak, why don't we all learn to do it.

MR. HILL—I think it may be generally conceded that we are pretty close to the theoretical limit of efficiency where we have an engine of considerable power designed for a certain specific duty. But, as Mr. Hemenway has stated, it is along the whole line and specially in the line of the engines that are not designed for specific duty, but for the usual market rates or the usual market service, that the greatest improvement can be looked for. As Mr. Rockwood has just said one of those lines of improvements is in the piston valve with which I have already had an experience, and generally a very satisfactory one, save for one particular. The valve was on an engine running at 275 revolutions, and every once in a while it was necessary for the attending engineeer to go around and give it a little twist, because it got working along on one line, and the oil got from under it and began to squeak. But as soon as it was twisted with the thumb and forefinger it was all right—for another ten or fifteen minutes. (Laughter.) The thing that it seems to me is of more interest to us as engineers is that we should take the means that we now have at hand in the line of a high-speed engine, especially for electric service, and apply it so as to get rather more economical results. In advising certain clients of mine concerning the installation of an electric light plant for a large building, I find that if the total number of lamps be assumed at 100 the engine capacity was based upon the full number of lamps and divided into three. The engines were intended to run all night. The consequence was that the total number of horse-power hours developed showed just 100 per cent. excess over the number of lamp hours which can be reasonably expected—the horse power hours required to develop the lamp hours required, that could be reasonably expected in that building. That is rather poor engineering, and yet, as near as I can learn, it follows rather closely the general line of practice in the installation of electric light engines. I then, for fun, tried various other combinations of units, and finally was enabled to find three engines each of a different size which gave only 125 horse-power hours instead of 200 horse-power hours, where 100 horse-power hours were required, and that seemed to be about as low as you could get, if you assumed that the losses would be about 20 per cent. for friction. But if there are any gentlemen here who have had any similar experience in regard to what the proper proportion is between the total number of lamps in a building, the number of lamps required to properly light a building, taking an office building as a standard, and the proper subdivision of engine power to run that building, I think that they could make a big saving in the coal bill if their experience could be practically applied to the design of some of our office buildings.

(To be Continued.)

Ex-Governor John H. Gear, of Iowa, who is a candidate for United States Senator in that State, got his nickname of "Old Business" from a celebrated notice he served on the officials of a railroad during the winter of 1879. At that time the northern part of Iowa was visited by a severe blizzard, which snowed under the line of the St. Paul Railroad, and, the company taking no steps to clear the tracks, great hardship was suffered by the settlers, who ran short of fuel

and other necessaries. The situation was explained to Governor Gear, and, becoming satisfied that greater hardship would result if the road was not opened, he sent the following dispatch: "To the officials of the Chicago, Milwaukee & St. Paul Railroad: If you don't open up the Milwaukee road to Emmetsburg, I will. John H. Gear, Governor." The road was opened after the receipt of this telegram.—*Evening Post.*

MANUFACTURES.

The Roanoke (Va.) Machine Works has resumed.

A new engine has been put in at the Stanley Works, New Britain, Conn.

The Gastonia (N. C.) Manufacturing Co. will put up a 200-light electric plant.

The new Taunton (Mass.) Mfg. Co. is about starting the manufacture of wrenches.

The Montague Iron Works at Grand Rapids, Mich., has resumed with a full force of men.

The Ahrens & Ott Manufacturing Co., of Louisville, Ky., is erecting an addition to its foundry.

Furnace No. 2, of the Dunbar (Pa.) Furnace Company, is being cleaned preparatory to a resumption.

Colebrook Furnace No. 1, at Lebanon, Pa., has again started up, giving employment to about 100 people.

The Waterbury Brass Company, Waterbury, Conn., started up their new rolling-mill on January 1st.

The Whitin Machine Works, builders of cotton machinery, Whitinsville, Mass., report a little better business.

Jonas Spaulding has bought property at South Milton, N. H., and will erect thereon a leather board factory.

The Ducktown Sulphur, Copper and Iron Company, Ltd., has resumed operations at its works in Ducktown, Tenn.

Fawcett's foundry, situated at Sackville, N. B., has been completely destroyed by fire at a loss estimated at $75,000.

The carpet manufactory of J. & J. Dobson, near Philadelphia, has been started up, giving employment to 1,800 hands.

The Duluth Manufacturing Company, of Duluth, Minn., has signed the scale and will put its mills into operation at once.

The knitting mills of Warner De Forest & Co., at Amsterdam, N. Y., and of E. J. Nelson in Middleville, N. Y., will resume work in a few days.

The Riverside, Belmont and La Belle iron companies, Wheeling, W. Va., have resumed work, giving employment to more than 2,000 men.

The Baltimore & Ohio car shops at Garrett, Md., which has been almost entirely shut down for four months, has started with a full force of 550 men.

The Camden Iron Works at Camden, N. J., which have been running with a reduced force on part time, have resumed operations in all departments.

At Lancashire, Pa., H. Shirk & Sons' cotton-mills, which have been idle several months, have started work. Three hundred hands are employed.

The American Machine Company, recently organized in England with a capital of $600,000, will, it is stated, build extensive works at Pawtucket, R. I.

The Solon (Me.) Steam-mill Co. has been organized for the purpose of manufacturing lumber. The president of the company is D. S. York.

The Cumming Foundry Company, of Chicago, capital stock $100,000, has been incorporated by Oscar Ludwig, R. D. Wardell and William S. Cumming.

D. McCarthy & Co., Syracuse, N. Y., are preparing a large building for use as a dry goods store. Engines and boilers about 200 horse-power will be required.

The Taylor Iron and Steel Company at High Bridge, N. J., have received the contract to make the new style armor piercing shell known as the "deck piercers."

The Niles Tool Company, Hamilton, O., have posted notices calling the old night gang back to work. They will work ten hours per day instead of eight as heretofore.

Furnaces Nos. 2 and 4 of the Reading (Pa.) Iron Company have resumed operations. Nearly all the departments are again at work and 1,000 hands are employed at the tube plant alone.

The mower and reaper works of Aultman Miller & Co., Akron, O., have been started with a force of 200 men. The works of the Akron Iron Company in the hands of a receiver will start.

The mills at Schaghticoke, N. Y., are running on full time again. The manufacturing interest, considering the depressed conditions of trade, has been unusually brisk in the village this winter.

The Reading Rolling-mill at Reading, Pa., has started up, giving employment to 350 men. It is stated that the firm have received an order which will keep the works running for some time.

The Noel mills plant at Satell Springs, Tenn., has started with increased capacity. It now makes 3,500 barrels of flour per day, and is one of the largest winter wheat and flour mills in the world.

The Iron Car Company, which concern succeeded the Iron Car Equipment Company, announce that the works in Huntingdon, Pa., will resume operations at an early date, giving employment to several hundred men.

A Bath (Me.) dispatch says: "It is not true as reported that wages will be cut 10 per cent. at the Bath Iron Works. The men can now work but nine hours instead of ten, but when the days lengthen they will return to ten hours."

A Martin's Ferry (O.) dispatch says: "The Etna, Standard and Laughlin Iron and Steel-mills and Spence & Sons' foundry have all resumed business, giving employment to 1,500 men. The prospects for a long and steady run are considered good."

The new factory of the McKay Metallic Fastener Co. at Winchester, Mass., is nearly ready and employment will be furnished at the outset to about 800 men. The new shop is built of brick, stone and iron. The main building is 100x70 feet; four stories.

The Cambria Iron Company, at Johnstown, Pa., have begun and are pushing the erection of a 28-inch rail mill, the estimated cost of which will reach $1,000,000. The foundation has been laid and part of the construction machinery is in position.

The hammer and boiler shops of the Schenectady Locomotive Works have started with a small force. The company has received an order to build three switch engines for the Central-Hudson road and two for a Vermont road. The other departments at the works will likely begin running soon.

A Huntington (Pa.) dispatch says: "The Iron Car and Equipment Company, which went out of existence several months ago, and which formerly conducted the car works at this place, has been succeeded by a new company known as the Iron Car Company. This concern intends to manufacture railway equipments in metals."

The report that a cut from 20 to 30 per cent. had been made in the wages of the employes of the Pullman Works, at Wilmington, Del., is denied by the superintendent. On the other hand, the wages of some of the men have been increased, while the force is being increased by 300 additional hands, bringing the number of employes up to 600 men.

The moquette mills of the Alexander Smith & Sons' carpet company, at Yonkers, N. Y., have started up. These mills have been closed for six months. The lower mills will start up later. The carpet mills employ 4,000 hands. The company has reorganized, with F. T. Holder as president, Harold Brown treasurer and Eugene Clark superintendent.

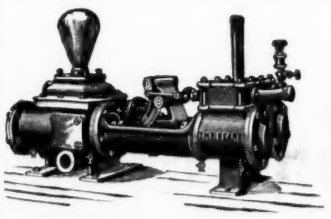
The George Burnham Company, Worcester, Mass., have issued a new catalogue illustrating, quite completely, a line of upright, bench and portable drills which they manufacture; also different forms of their well-known clamp drills. The upright drills are for hand and power use, back-geared and plain, and of a variety of sizes.

The Fowler Foundry Company, of Chicago, has leased for a term of years the plant of the Northern Steel Co., in that city, and has entirely refitted and remodeled it. The company will make steel castings of every description, from twenty pounds up, paying special attention to the manufacture of mechanical and electrical machine and railroad work.

At New Castle, Pa., a number of manufacturing concerns which have been idle more or less are again in operation, with good prospects for continuous running. Among those concerns who have resumed may be mentioned the Arethusa Iron Works, Etna Iron Works (Limited), New Castle Steel and Tin Plate Company, and New Castle Wire Nail Company.

The Phœnix Horseshoe Company, of Poughkeepsie, N. Y., has just completed a new plant at Joliet, Ill. The main structure is 156x76 feet, with a lean-to 76x40 feet, the bar-mill is 144x121 feet. Another department for the heating of billets and the forming of shoes is 200x70 feet. All of the buildings are arranged carefully, are conveniently located, and so placed that they can be easily extended.

While general business is quiet at St. Louis, the volume having decreased perceptibly since the latter part of November, some of the machine



THE DEANE
OF HOLYOKE
STEAM PUMPS
DEANE STEAM PUMP CO.,
HOLYOKE, MASS.

THE MASON LEVER VALVE

Is made essentially the same as the "Mason Balanced Valve," with the substitution of yoke and lever with weight attached for the bonnet and knuckle joint of the balanced valve. The lever valve will be found useful in controlling the supply of water in tanks by attaching to a ball float. It can also be used to control steam pumps in tank service, by placing the valve in the steam supply pipe to the pump and connecting the lever with a ball float placed in the tank. There is no lost motion in any of the joints, a fact which those desirous of close regulation will appreciate. These valves can be furnished either as piston or seated valves. The latter style is steam tight.

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THE FINEST QUALITY OF STEEL
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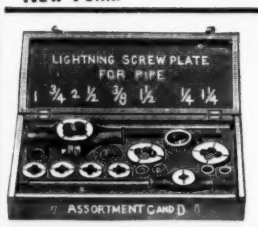
FOR TOOLS, DIES, MILLING CUTTERS, ETC.



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Also many new assortments for Bolts.
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SAVES LABOR in being able to run at GREATLY INCREASED SPEEDS. FEWER GRINDINGS. No WASTE in redressing.
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Ready Made Cut Gears.
Ready Made Cast Gears.
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Gears Made to Order.
Gear Cutting.
Gear Book, 15 cents.
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Lexington, Mass.,
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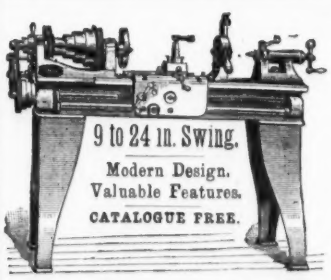

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Manufacture ENGINE and SPEED Lathes, which are specially adapted and recommended for general Machine and Jobbing Shop, Electrical and Experimental Work.
High Grade Tools at Low Prices: Planers, Shapers, Drills, Emery Grinders, Grindstone Frames, Shop Outfits in Tools and Supplies.
Write for CATALOGUE and PRICES.

BORING AND TURNING MILLS.
37, 51 and 62 Inch Swing, with Two Regular Heads.
42 INCH SWING, WITH TURRET HEAD, AND SCREW CUTTING ATTACHMENT.
All gears accurately cut. All feeds positive.
Machines are self-contained and therefore do not require an expensive foundation.
BRIDGEPORT MACHINE TOOL WORKS,
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SMOKE STACK PAINT
Used on the ships of the U.S. Navy and by the prominent Steamboat and Transportation Companies. The only paint supplied in colors which has given absolute satisfaction where forced draught is used.
READY FOR USE
ALL ORDINARY SHADES.
H. W. JOHNS MFG CO.
87 MAIDEN LANE, NEW YORK.
NEW YORK JERSEY CITY CHICAGO PHILADELPHIA BOSTON LONDON

shops have more work on hand than at any other time since last spring This runs more in the line of repairs, however, and may be expected to still further augment as cold weather and the holidays close down the largè industrial plants —*Labor Tribune.*

Gilbert & Barker Manufacturing Company, 90 John street, New York, announce that owing to the death of Mr. W. S. Collins, licensee of the Aerated Fuel Company. the business will be carried on by them as general agents for the Aerated fuel process in the United States. J. C. Faulkener, M. E., who has been connected with the Aerated Fuel Company for the past six years as an expert in constructing furnaces, and installing oil fuel plants, will give his personal attention to all matters pertaining to this business.

J. Wyke & Co. (Fine Machinists' Tools), East Boston, Mass., write us: Our business during the first six months of 1893 was excellent, in fact driving. The last six months' business has fallen off very much indeed, and though orders for our goods are still numerous they are very much shrunken in size. Many of our "patent key-seat gauges" and "patent center, depth, angle and twist drill gauges" are in use in many of the government works of the United States and Europe, also in the shops of the machine, engine, tool and steam pump builders of prominence in this country, and to all inquiries we have made of these firms as to what they think of the merits of these tools, they say they are the handiest tools in the shop, not only for the uses advertised, but for many others also. As for business in 1894 we do not look for much improvement till "tariff tinkering" stops.

Clayton Air Compressor Works, 43 Dey street, New York, write us: While our shipments during 1893 did not equal those of the previous year—which was the best in our history—our trade was uniformly good, and we are now working full time and full capacity. In addition to our usual trade amongst the mining, tunneling and railway interests, the increasing use of our line of machinery in transmitting natural gas through pipes, for refrigerating and ventilating purposes, supplying divers in submarine operations, working pneumatic riveters, cranes, hoists and tools of all descriptions, vulcanizing wood, removing rubber hose from mandrels, operating transmission tubes, charging pneumatic tires, compressing carbonic acid gas, charging automatic sprinklers, elevating acids and other liquids, agitating molasses and solutions of every kind, operating oil fires and lights, testing tinware, pipe and hose, experimental purposes, etc., has tended to swell the volume of orders, and judging from the number of requests which we are daily receiving for copies of our recently issued catalogue, together with estimates on our compressors for the above mentioned and new lines of duty, we believe that the year just begun will not prove as dull a one as has been generally predicted. Our pamphlet on the "Widening Use of Compressed Air," recently noticed in your editorial columns, has been extensively called for by your subscribers.

J. D. Roberts, Receiver for Lookout Iron Company, Harriman, Tenn., by W. B. Winslow, treasurer for receiver, sends us the following: "In your issue of the 4th inst. you say, 'the management of the Lookout Iron Company, Harriman, Tenn., are attempting to operate their works without a scale, but have not succeeded in securing any one to enter their service. The works have been idle a long time, but the men will not resume work without scale rates and re-organization.' This is not a correct statement. The Lookout Iron Company is now in the hands of a receiver, and the receiver recently proposed to the men for merly employed in the mill, that he would start up the mill, at certain named prices, which were less than the scale, for the purpose of *working up some raw material now on hand.* A large majority of the men formerly employed in the mill favored going to work, but one or two objected on the grounds that they did not wish to become 'scabs' in order to secure a job for such a short time, and as the receiver made the proposition principally to *give employment to the men and save them from suffering* during the winter, he did not insist upon running the mill. If there was a demand for iron sufficient to justify the running of the mill continually, there are sufficient applications on hand for work at less than 'scale prices and without organization' to justify me in saying that the mill could be completely manned in less than ten days."

Graham Twist Drill and Chuck Company, Detroit, Mich., write us: The year 1893 showed an increase of total sales over 1892. This at first might appear rather extraordinary, but the circumstance is accounted for by the fact that the first six months of the year were about double that of 1892. Since July 1st we have suffered like the rest, and trade has fallen off completely, but during December we have had quite a revival, and have shipped several large orders. We have been satisfied with the result, on the whole, as our increased trade during the early months of the year demonstrated that the demand for the increased adoption of the grooved shank system was a healthy one and was bound to continue. We have increased our shop materially during the year, and are prepared to fill all orders sent to us. We have added several improvements to our chucks, which add to their efficiency. We have gotten out a new "tool room chuck" (which has been illustrated in your paper) which is a specially accurate and efficient tool. We have also added the reducers which enable one chuck to take drills ranging from $\frac{3}{32}$" to 2½', both inclusive. We have been running on reduced force and part time ever since July, but have made no reduction in wages although the labor market is overstocked and low wages prevail in this district. We look forward to a fair spring and good fall trade, and an early return of prosperity, relying on the strength of the country to quickly rally from any temporary prostration.

Machinists' Supplies and Iron.

NEW YORK, January 13, 1894.

Iron—American Pig—We quote Standard Northern brands, No. 1 Foundry, $13.00 to $14.00; No. 2, $12.50 to $13.25; Gray Forge, $11.75 to $12.50. Southern brands of good quality are obtainable at $13.00 to $14.00 for No. 1 Foundry; $12.00 to $13.00 for No. 2, and $11.25 to $12.00 for Gray Forge.

DON'T ACCEPT ANY SUBSTITUTE FILE.
INSIST ON HAVING
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NICHOLSON FILE CO.
PROVIDENCE, R. I., U. S. A.
3000
VARIETIES FILES
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THE BERLIN IRON BRIDGE CO.
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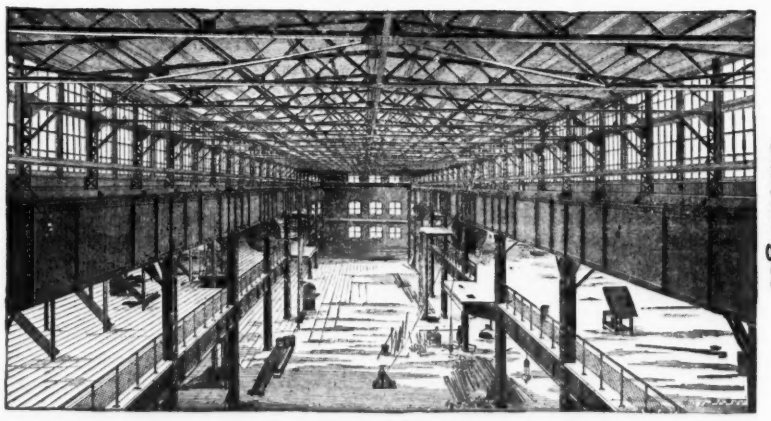
Engineers, Architects and Builders of

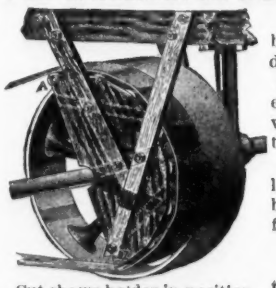


Iron and Steel Bridges and Buildings.

The above illustration taken direct from a photograph, shows the construction of a Machine Shop designed and built by us for the Link Belt Machinery Co., at Chicago, Ill. The building is 124 feet in width by 407 feet in length Each side wing is 42 feet in width and two stories high. The central portion of the building is 50 feet in width controlled by a hydraulic crane with a travel the full length of the building. This is probably one of the best designed modern Machine Shops to be found in the United States.

SEND FOR OUR ILLUSTRATED CATALOGUE.

THE WELLINGTON BELT HOLDER.



Cut shows holder in position beside driving pulley.

Large or small belts shifted from driving pulley and held at rest, and easily slipped back when machine is to be started.

It dispenses with loose pulleys, saves belts, and is perfectly safe.

It is *cheap.*

Write for descriptive circular and price list to

COOKE & CO.,
163 & 165 WASHINGTON STREET, NEW YORK,
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Political Economy, the Tariff and the Currency
JUST READY.

A Catalogue of Books and Pamphlets on Social Science, Political Economy, the Tariff, the Currency, the Finances, Population, Pauperism, Charity, the Land Question, etc. 32 pages, 8vo, sent free to any one in any part of the world who will furnish his address,

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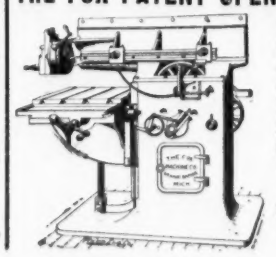

No springing of ram. No overhanging table. Quick Return, Stroke Under Perfect Control. Can be Instantly Adjusted 1 16 in. or 24 in. No Screws to Monkey with. Powerful, Quick, Accurate. Write for circular.

The Fox Machine Co.,
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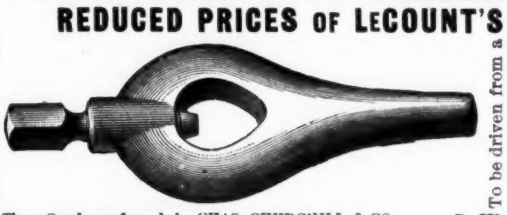
REDUCED PRICES OF LECOUNT'S STRAIGHT TAIL DOG.

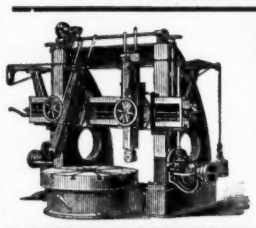


To be driven from a Stud in the Face Plate.

No.	INCH.	PRICE.	No.	INCH.	PRICE.
1	¾	$0.60	10	2¼	$1.35
2	⅞	.70	11	2½	1.45
3	1	.70	12	3	1.60
4	1⅛	.80	13	3½	1.80
5	1¼	.80	14	4	2.10
6	1⅜	.95	15	4½	2 75
7	1½	.95	16	5	3.25
8	1¾	1.10	17	5½	4.00
9	2	1.20	18	6	5.00
1 Set to 2 in.		7.80	Full Set.		31.10

These Goods are for sale by CHAS. CHURCHILL & CO., L't'd, 21 Cross St., London, England.

C. W. LeCOUNT, South Norwalk, Conn.



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14 SIZES FROM 5 TO 20 FEET.
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MANUFACTURERS OF THE CELEBRATED
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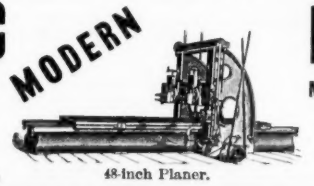
METAL-WORKING MACHINES,



48-inch Planer.

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ALL KINDS IN STOCK.
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Established a century ago.
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"Star" Foot Lathe Swings 9x25 in.
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Screw Cutting Automatic Cross Feed, etc.
Scroll Saws, Circular Saws, Lathes Mortisers.
Catalogue Free of all our Machinery.
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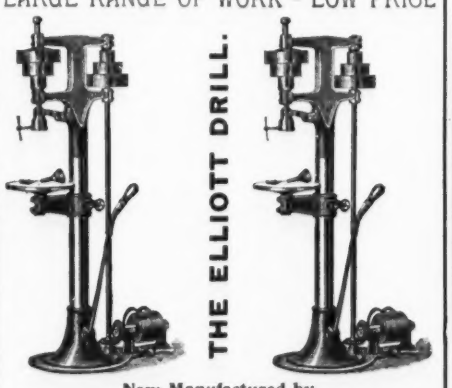
Gun-Iron Air Furnace Castings, Engine and Machinery Castings, Loam and Dry-sand Castings, Pneumatic Tubes and Caissons for Bridge-Piers, Globe Special Castings for Water Works, The Venturi Meter, Special Machinery, Accurate and Heavy Machine Work.

The Elliott Drill Press
FOR ANY LIGHT WORK
LARGE RANGE OF WORK - LOW PRICE



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Friction Pulleys, Clutches and Elevators,
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FOR
WATER WORKS.
SIMPLE, COMPOUND, OR TRIPLE EXPANSION, HORIZONTAL OR VERTICAL
HIGHEST DUTY GUARANTEED.
COMPLETE DESCRIPTIVE PAMPHLETS ON APPLICATION.
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Antimony—The market is dull. We quote L. X., 9⅝c. to 9½c.; Cookson's, 9.10c., to 10½c.; Hallett's, 9c. to 9¼c., and U. S. French Star, 10c.

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Copper—Prices have a lower tendency. Lake Copper is quoted at 10⅛c. to 10.20c., and Casting Copper is held at 9⅜c. to 9½c. Consumers do not buy any more than to cover their immediate wants.

Lead—The tone of the market is improving, and there is a better demand at the low prices. Good commercial brands can be had at 3.20c. delivered in New York.

Spelter—The market is steady at 3.65c. for New York delivery. The demand is light.

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"Situation and Help" Advertisements only inserted under this head. Rate 30 cents a line for each insertion. About seven words make a line. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.

Wanted—Foremanship by one of exp.; engines, pumps, or gen. repairing. Indicator, AM. MACH.

Wanted—Situation in charge of designing & mfg. steam, hydraulic or mining mach'y. M. E., AM. MACH.

Engineer wants pos. as first ass't in some electric light or power station. Engineer, AM. MACH.

Mech. engineer and draftsman is open for engagement. R., AMERICAN MACHINIST.

Situation wanted by foreman patternmaker; electric & mach'y, steady, refs. Box 150, AM. MACH.

Wanted—An assistant draftsman. Apply by letter to John Rohland, care The Coxe Iron Mfg. Co., Drifton, Luzerne County, Pa.

Wanted—Position in charge of sales of machinery or tools, N. Y. or Chicago preferred. Address Experience, AMERICAN MACHINIST.

Experienced traveling salesman wants position; well acquainted with trade and mfrs. and can sell goods; A1 refs. Address Box 146, AM. MACHINIST.

Wanted—Situation by draftsman and shop supt. (Am.) 35 years old; exp'd in power transmissions & gen. mill furnishing; competent to plan & estimate on erection, etc.; good refs. J. P., AM. MACHINIST.

Wanted—A pos. by draftsman, good ref., 12 yrs' exp. in steam, hydraulic and other work as chief designer; would take interest; pump work a specialty. C., 238 Kirtland St., Cleveland, O.

Wanted Immediately—A first-class experienced mechanical engineer and draftsman, capable of designing high grade compound condensing engines, air compressors, heavy hoisting and mining machinery. Good salary and engagement for one year; none but experienced, sober men need apply. Give qualifications, experience, age, references, and salary wanted. Corliss AMERICAN MACHINIST.

A mechanical engineer, 36 years, experienced in the design and construction of high grade engines, special tools, and general machinery, competent in handling men and work systematically, desires position as superintendent of works or chief of engineering department, and is open for immediate engagement. Address Competent, AMERICAN MACHINIST.

Asst. foreman boiler maker, locomotive works, age 35, thorough mech., make estimates, wants pos. as foreman, or contract to build or rebuild boilers, tanks, reset tubes, etc.; R. R. shop pref'd; refs. A1. "Temperate," AMERICAN MACHINIST.

✣ MISCELLANEOUS WANTS ✣

Advertisements will be inserted under this head at 35 cents per line, each insertion. Copy should be sent to reach us not later than Saturday morning for the ensuing week's issue. Answers addressed to our care will be forwarded.

Cheap 2d hd lathes & planers. S. M. York, Clev'd, O.

Auto. Steam Flue Cleaners. Kelley Co., Erie, Pa.

For Sale—Second-hand drill presses, engine lathes & planers. Dietz. Schumacher & Co., Cincinnati, O.

Light and fine machinery to order; Foot Lathe Catalogue for stamp. E. O. Chase, Newark, N. J.

Hand pipe threader 4", $67; monitor lathe, $95; screw-cutting lathes, all sizes, cheap. 229, AM. MACH.

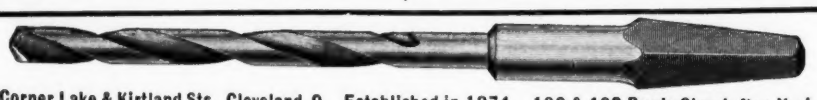
Calipers, Surface Gauges, etc. Catalogue free. Send for it. F. A. Welles, Milwaukee, Wis.

Agents—$5 Speed Gage, new, valuable, sells; shows constantly speed and slightest variations; Geo. T. McLauthlin & Co., 120 Fulton St., Boston.

Introduction and negotiation of American patents and machinery to English manufacturers and agents. Write for circular to Geo. Richards, M. I. M. E., Mechanical and Consulting Engineer, No. 5 Laurence Pountney Hill, London, England.

We will pay 50 cents each for copies of the AMERICAN MACHINIST of December 4, 1886 issue; must be unsoiled and in good condition. AMERICAN MACHINIST PUBLISHING COMPANY, 203 Broadway, New York.

Correspondence wanted with a reputable concern manufacturing a standard line of goods, with a view of consolidating. Have a large general jobbing foundry & mach. business, but would like to mfr. some standard article. Box 149, AM MACH.



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MACHINE TOOLS OF MODERN STYLE

in FIRST-CLASS ORDER will be SOLD LOW BEFORE REMOVAL out of a SHOP JUST BOUGHT OUT.

Gould & Eberhardt 25 in. Upright Drill, with Back Gear and Automatic Feed.
Blaisdell, 40 in., Upright Drill, extra heavy, with Back Gears and Automatic Feed.
Blaisdell Engine Lathe, 13 in. x 6 ft.
Fitchburg " " 14 " 8 "
Perkins " " 15 " 6 "
Ames " " 16 " 8 "
Hendey " " 18 " 10 "
Putnam " " 20 " 8 "
Fitchburg " " 24 " 12 "
Lodge-Davis-Fox Monitor Lathe, 15 in. x 6 ft.
Bogert Hand Lathe, 14 in. x 6 ft.
Gould 8 in. Stroke Crank Motion Shaper.
Improved 15 in. " " "
Improved 36 in. Gear Cutter—cuts Spur Bevel—Spiral and Worm Gears, extra heavy.
Universal Milling Machine, with all attachments.
Lincoln Milling Machine.
Upright Boring and Turning Mill, 38 in. swing with Two Heads, having Automatic Feeds.
Brown & Sharpe Vertical Turret Machine, 36 in.
Whitcomb Planer, 20 in. x 4 ft.
Hewes & Phillips Planer, 35 in. x 7 ft.
Ferracute Inclined Frame Punch Press.
Stiles Pattern No. 2 Punch Press.
Ferris & Miles 300 lbs. Steam Hammer,

LARGE STOCK, NEW IMPROVED TOOLS OF THE BEST STANDARD MAKES.

Boiler Bending Rolls, Improved Style, 6, 8 and 10 ft., with Hinged Housings.

J. J. McCABE,
SUCCESSOR TO
E. P. BULLARD'S
N. Y. Mach'y Warerooms.
14 Dey St., NEW YORK.

A SPLENDID 16-INCH LEVER DRILL

CAT. NO. 3. AT VERY LOW PRICE.

THE GEO. BURNHAM CO., Worcester, Mass.

SECOND-HAND MACHINE TOOLS.

HAND LATHES.
3 10 " Garvin.
3 12 " "
1 10 " Reed.
3 20 " x 8 ft. Ames Mfg. Co.
1 20 " x 6 ft. Gould & Eberhardt.
2 22 in. x 8 ft. Ames Mfg. Co.

TURRET LATHES.
1 15 in. x 5 ft. Jones & Lamson.
1 " " Lodge & Davis.
1 " " Hendey Machine Co.

MILLING MACHINES.
1 No. 1½ Garvin.
1 " 5 Brainerd.
1 " 2 Garvin.
4 " 1 Pratt & W. Lincoln.
2 F. E. Reed Lincoln.
1 No. 4 Garvin, Rack Feed.
1 Merritt Heavy Back Geared.
No. 3 Brainerd Standard Universal.

SCREW MACHINES.
2 No. 00 Garvin, W. F.
1 " 1 " "
2 " 2 " "
1 No. 2 Brown & Sharpe.
1 " 3 " "
1 " 5 " "

POWER PRESSES.
1 Small Camfee.
1 No. 3 Eaton.
1 " 18 Bliss.
1 " 2 Stiles.
1 " 3 "
1 " 6 Niagara.
1 " 21 Bliss.
1 " 53 "
1 " 36 "
2 " 7 " Heavy Drop.
1 " 7 " Foot Press.

MISCELLANEOUS.
2 No. 1 Garvin Gear Cutter.
1 4 in. Curtis Pipe Machine.
1 2 " Bignal & K. Pipe Machine.
1 No. 3 Diamond Grinder.
3 " 2 " "
1 " 2 Garvin Cutter Grinder.
2 Garvin Screw Slotters.
2 No. 2 Brown & S. Tappers.
1 6 in. Bement Slotter.
1 10 in. Newton Slotter.
1 No. 2 Nat. Single Bolt Cutter.
1 " " " Double " "

Also, large number of other machines. Write for complete list and detail description.

THE GARVIN MACHINE CO.,
LAIGHT & CANAL STS., NEW YORK.

Shriver's New York Traveling Cranes

FOR HAND OR ELECTRIC POWER.

T. Shriver & Co. 333 East 56th St., NEW YORK.

MANUFACTURERS OF
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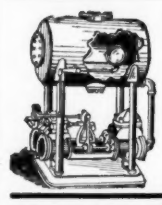

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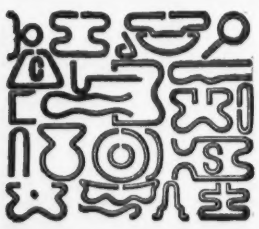

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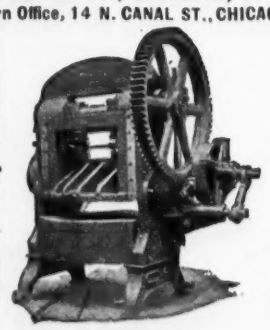

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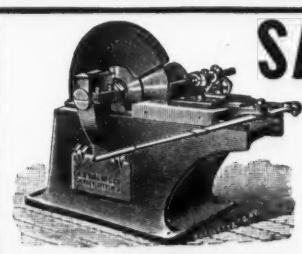

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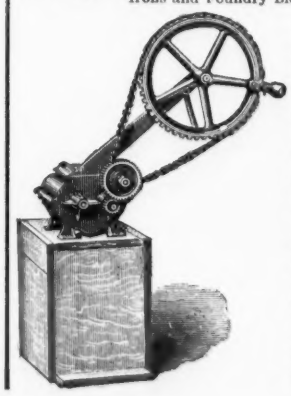

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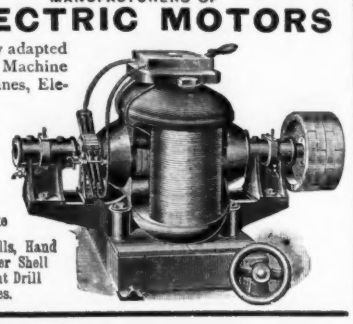

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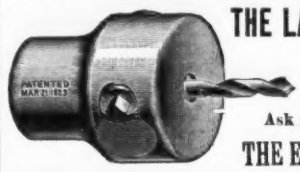
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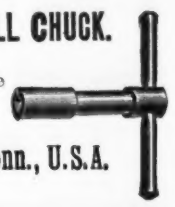
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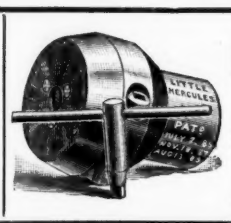

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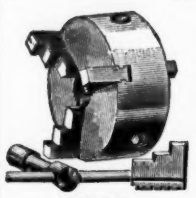
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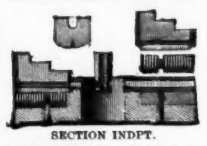
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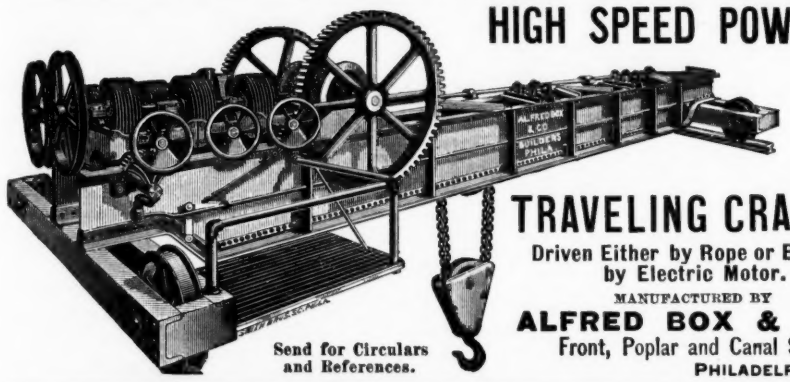
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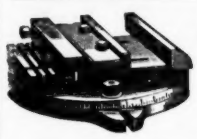
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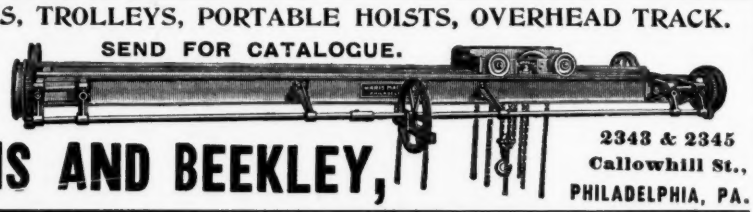
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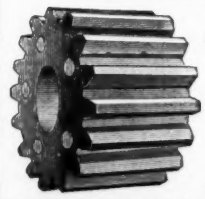
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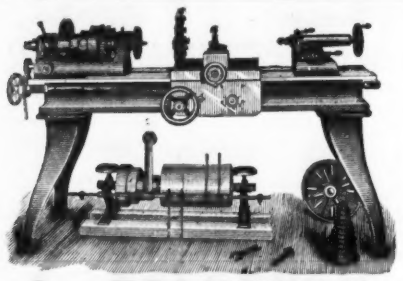

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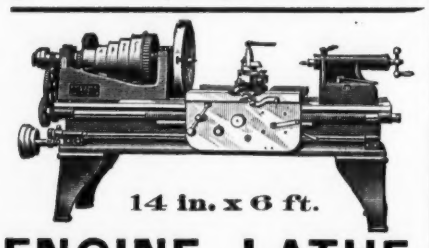

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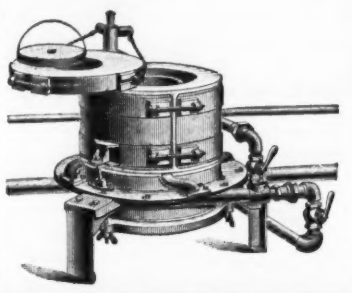

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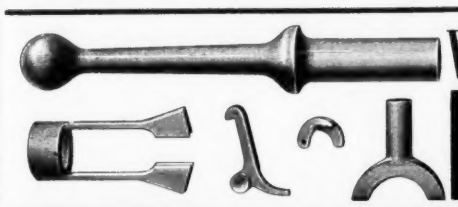

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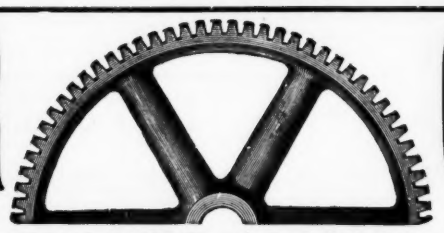

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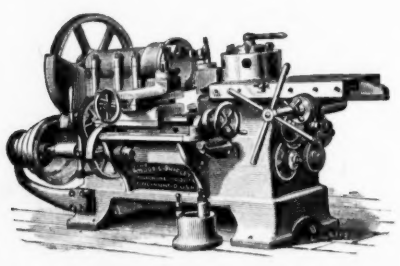

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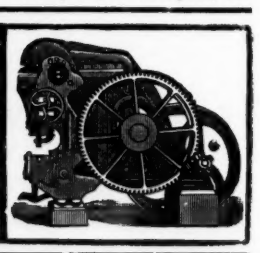

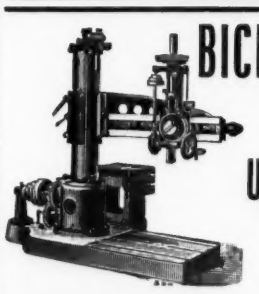

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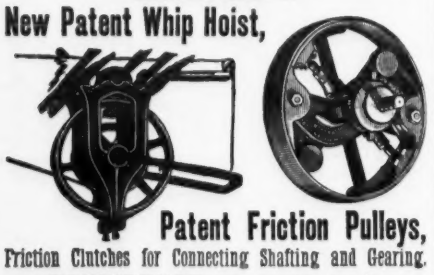

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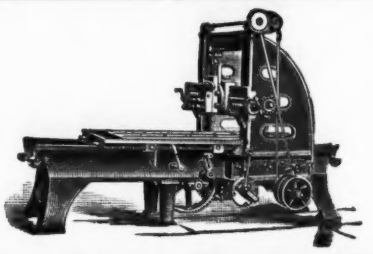

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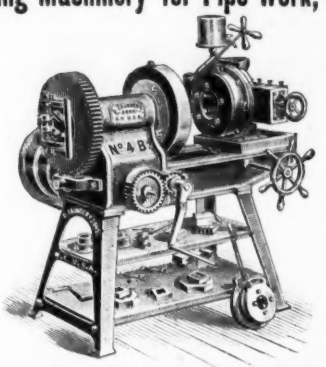

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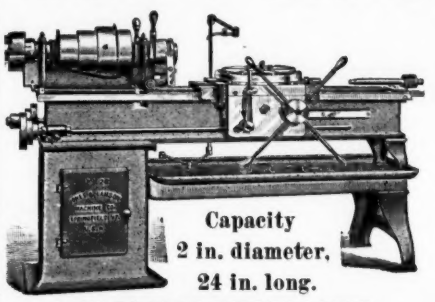

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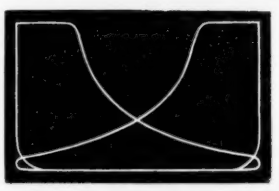

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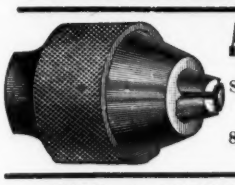

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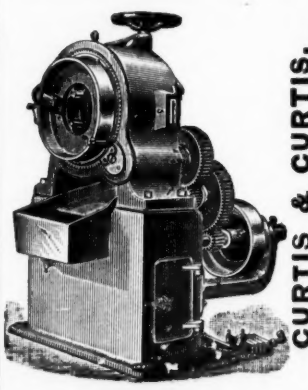

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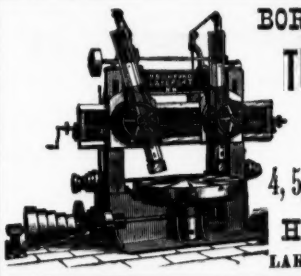

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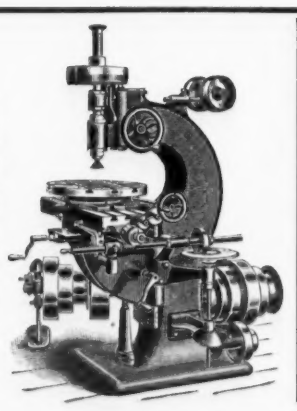

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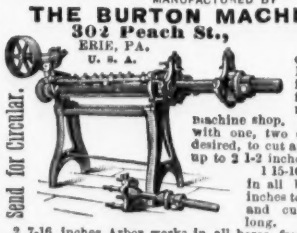

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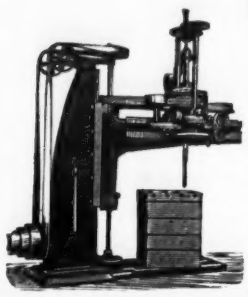

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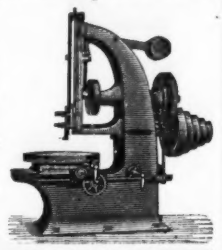

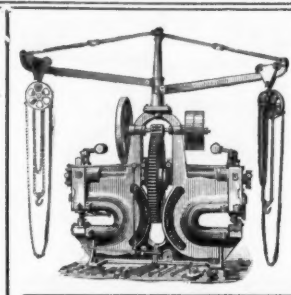

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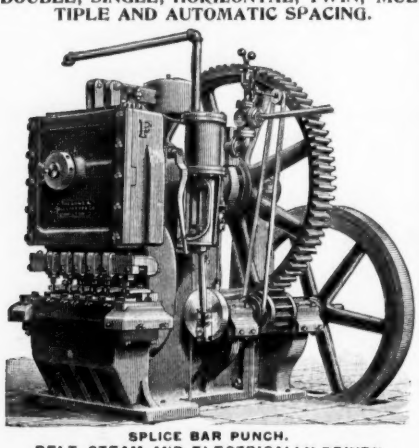

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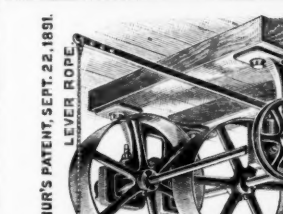

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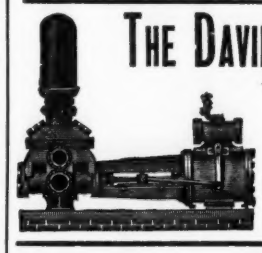

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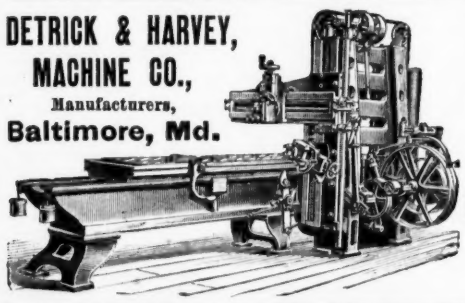

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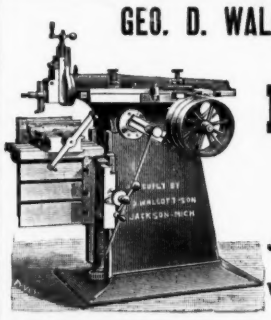

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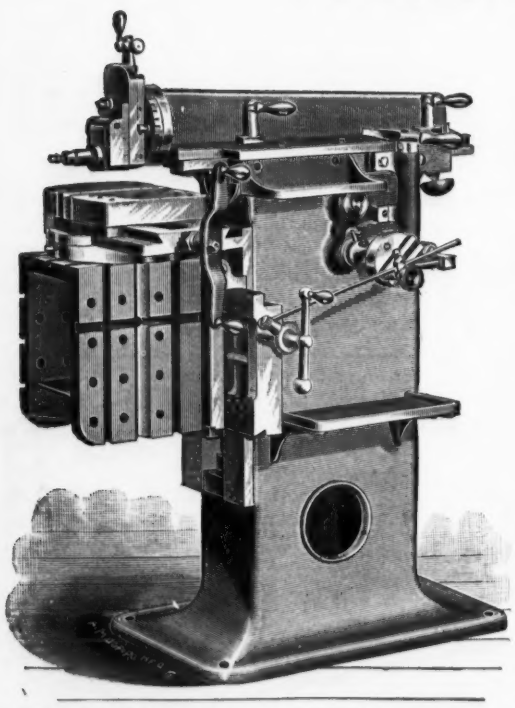

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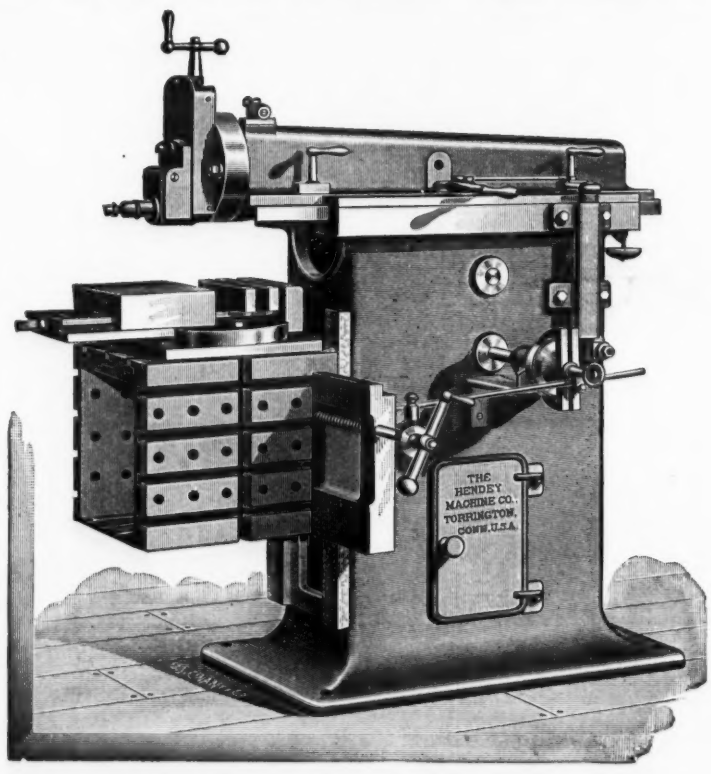

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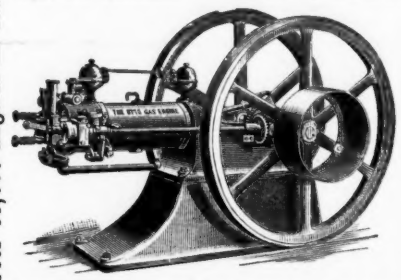

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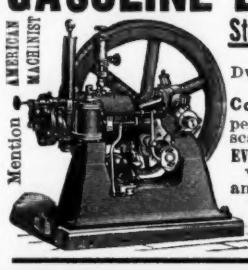

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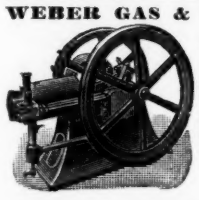

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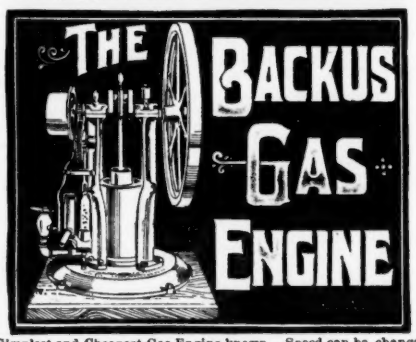

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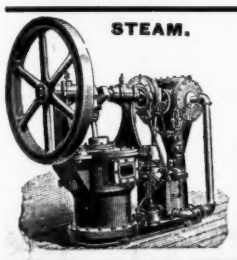

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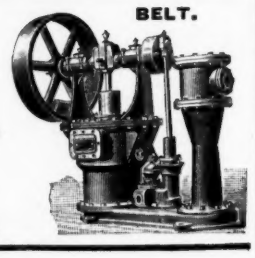

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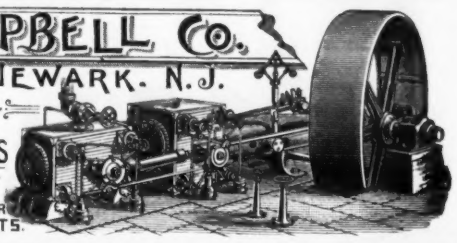

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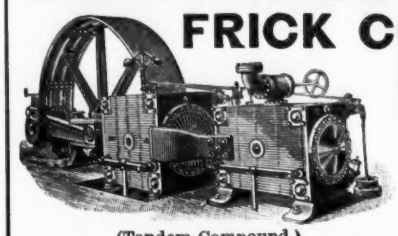

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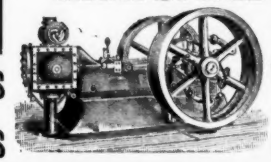

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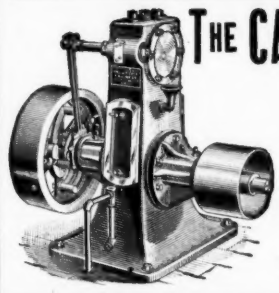

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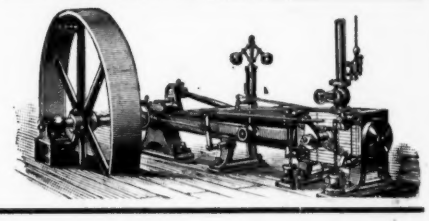

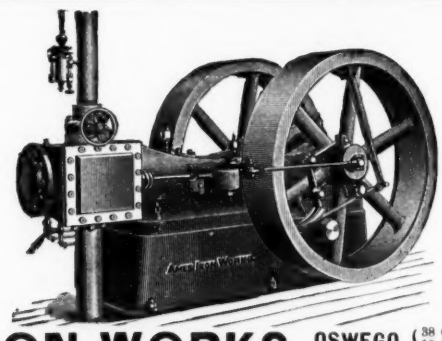

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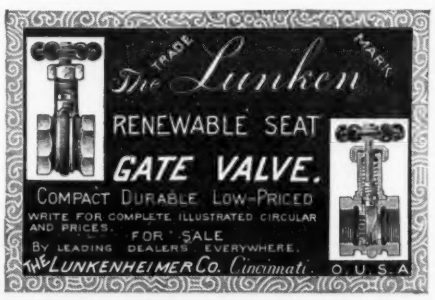

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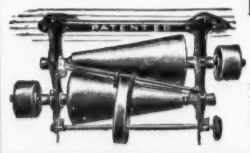

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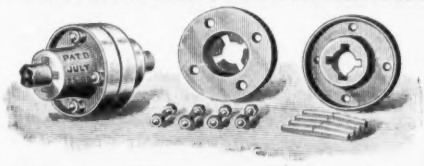

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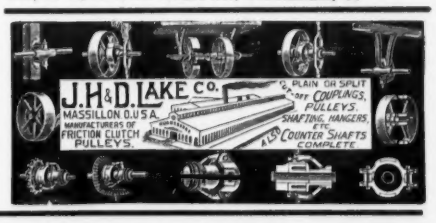
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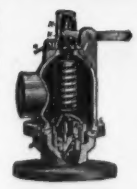

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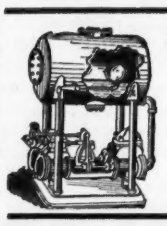

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in FIRST-CLASS ORDER will be SOLD LOW BEFORE REMOVAL out of a SHOP JUST BOUGHT OUT.

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No. 3 Brainerd Standard Universal.

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1 Small Camfee.
1 No. 3 Eaton.
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1 " 3 "
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2 " 7 " Heavy Drop.
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2 Garvin Screw Slotters.
2 No. 2 Brown & S. Tappers.
1 6 in. Bement Slotter.
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1 " " Double " "

Also, large number of other machines. Write for complete list and detail description.

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Shriver's New York Traveling Cranes

FOR HAND OR ELECTRIC POWER.

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TRAVELING CRANES of 1½, 2, 3, 5 and 10 Tons capacity, to be operated by Hand, or wholly or in part by Electricity.

A SPLENDID 16-INCH LEVER DRILL

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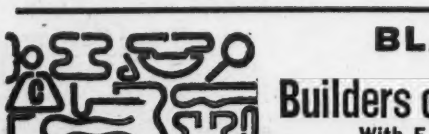

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NEW AND SECOND-HAND.

Boiler Shop Outfit, Bement, Miles & Co. make.
93 in. Hydraulic Riveting Machine, Pump and Accumulator.
10 Ton Crane Bridge, 24 ft. x 20 ft.
Plate Planer, 16½ ft., one setting. 1 in. Plate.
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Boiler Rolls, 8 ft. 3 in. between Housing. Cheap.
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60 in. Swing Post Drill. Hilles & Jones.
Full Line Lathes, Planers, Drills, Milling Machines.
Screw Machines, Shapers, Profiling Machines, etc.
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11 in x 4 Hand Lathes. Cheap.
Lot of **Polishing Machinery**, **Dynamo** for Electroplating, Drop Hammer, Belting, etc., etc.

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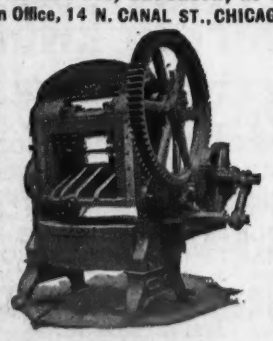

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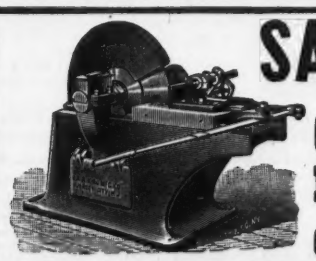

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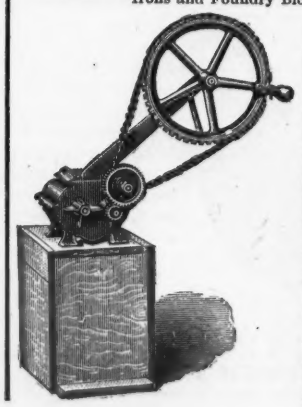

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